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P-252

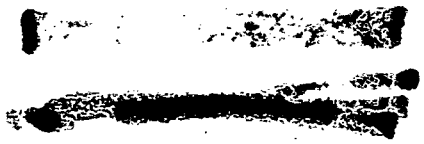
Research and Technology Objectives and Plans Summary

Fiscal Year 1992 Research and Technology Program

[redacted]

Date for general release: January 1994

NASA National Aeronautics and Space Administration
Scientific and Technical Information Program
Washington, DC
1992



Available through the NASA Center for AeroSpace Information, P.O. Box 8757, Baltimore, MD 21240-0757.

INTRODUCTION

This publication represents the NASA Research and Technology Program for FY 1992. It is a compilation of the "Summary" portions of each of the RTOPs (Research and Technology Objectives and Plans) used for management review and control of research currently in progress throughout NASA. The *RTOP Summary* is designed to facilitate communication and coordination among concerned technical personnel in government, in industry, and in universities. We believe also that this publication can help to expedite the technology transfer process.

The *RTOP Summary* is arranged in five sections. The first section contains citations and summaries of the RTOPs listed in ascending accession number order. Following this section are four indexes: Subject, Technical Monitor, Responsible NASA Organization, and RTOP Number.

The Subject Index is an alphabetical listing of the main subject headings by which the RTOPs have been identified.

The Technical Monitor Index is an alphabetical listing of the names of individuals responsible for the RTOP.

The Responsible NASA Organization Index is an alphabetical listing of the NASA organizations which developed the RTOPs contained in the Journal.

The RTOP Number Index provides a cross-index from the RTOP number assigned by the responsible NASA organization to the corresponding accession number assigned sequentially to the RTOPs in *RTOP Summary*.

As indicated above, responsible technical monitors are listed on the RTOP summaries. Although personal exchanges of a professional nature are encouraged, your consideration is requested in avoiding excessive contact which might be disruptive to ongoing research and development.

Any comments or suggestions you may have to help us evaluate or improve the effectiveness of the *RTOP Summary* would be appreciated. These should be forwarded to:

National Aeronautics and Space Administration
Office of Aeronautics and Space Technology
Washington, DC 20546-0001
Attn: Glenn Fuller
Director, Resources and Management Systems Office (RB)

Richard H. Petersen
Associate Administrator for
Aeronautics and Space Technology

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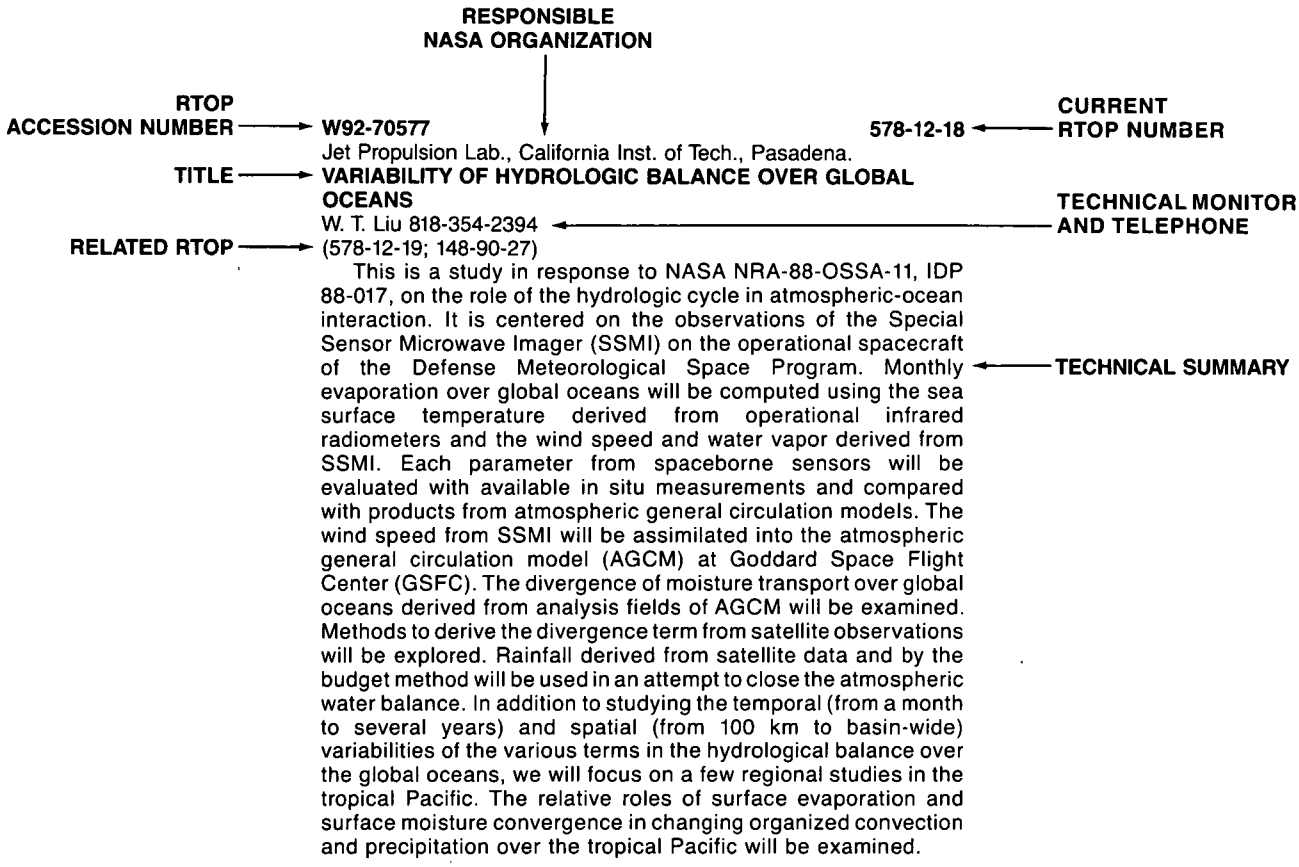


RESEARCH AND TECHNOLOGY OBJECTIVES AND PLANS

a summary

FISCAL YEAR 1992

OFFICE OF AERONAUTICS AND SPACE TECHNOLOGY

Aeronautics Research and Technology Base

Aerodynamics Research and Technology

W92-70001 **(21) 505-59**
Ames Research Center, Moffett Field, CA.
APPLIED AERODYNAMICS RESEARCH AND TECHNOLOGY
F. R. Bailey 415-604-5065
(505-68-00; 506-40-00; 763-21-00)

The objectives are to: (1) advance fundamental understanding of basic aerodynamic and thermodynamic processes and to develop predictive capabilities for analysis and design optimization of advanced aerospace vehicles and their propulsion systems; and (2) provide the necessary research and technology development for an improved validated base of new aerodynamics and flight dynamics technology for application by industry to future generations of both civil and military flight vehicles. A combination of computer simulations and experiments will be used to study flow over individual aerospace vehicle components, as well as complete configurations. Codes applicable to practical fluid dynamics problems will be developed to transfer the technology to the aerospace community. Wind tunnel experiments will be conducted to verify codes and validate prediction techniques. Analytical, ground-based and flight research investigations of a broad class of vehicles (subsonic transport, general aviation, rotorcraft, fighter/attack, and hypersonic) will be conducted. Efforts will also include B-52 launches of Pegasus and development of fiber optic sensor integration (FOCSI) and flight test. This RTOP also funds the Wind Tunnel Revitalization and Facility Maintenance Programs.

W92-70002 **(22) 505-59**
Lewis Research Center, Cleveland, OH.
APPLIED AERODYNAMICS RESEARCH AND TECHNOLOGY
L. A. Povinelli 216-433-5818
(505-62-00; 505-69-00)

The objective is to advance the fundamental understanding of the internal fluid mechanics of hypersonic propulsion systems. The research effort is focused on the modeling of the physics of boundary layer transition, shock interactions, high speed shear layer development and applications of the modeling to CFD codes for airframe/propulsion integration. Experimental, analytical and numerical studies will be conducted to study the physics of boundary layer transition in internal flows, shock-boundary layer interactions and shear layer development and augmentation for high speed mixing applications. Direct numerical simulations will be performed to model transition physics and turbulence development. Fundamental experiments will be conducted over a range of subsonic to hypersonic flows. Models will be developed to describe internal flow physics and incorporated in 3D Navier-Stokes codes which will be applied to airframe-propulsion integration for hypersonic aircraft. The research effort will be performed in-house and through university grants.

W92-70003 **(23) 505-59**
Langley Research Center, Hampton, VA.
AERODYNAMICS RESEARCH AND TECHNOLOGY
R. V. Harris, Jr. 804-864-6048

The objective is to develop an advanced and validated base of new aerodynamics technology for application to future generations of civil aircraft, rotorcraft, and fighter aircraft. An additional objective is to accelerate technology development in support of the hypersonic cruise/transatmospheric vehicles. Ground-based, flight, and computational facilities are used to generate the advanced technology needed to accomplish the cited objectives. Wind tunnel tests and consultation to DOD, industry, and other agencies are provided consistent with available resources.

W92-70004 **(55) 505-59**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
AERODYNAMICS RESEARCH AND TECHNOLOGY
L. M. Mack 818-354-2138

This part of the Transition/Turbulence Element of the Aerodynamics research and technology program applies to the research area of laminar instability and transition. The overall objective is an understanding of the detailed physical processes that lead to boundary-layer transition, and the application of this knowledge to the prediction and control of transition. The plan is to use numerical, analytical and experimental techniques to investigate the following four problems: (1) the mechanisms by which various external disturbance sources interact with the boundary layer to produce and modify instability waves and other disturbances (receptivity problem); (2) the propagation through the boundary layer of the instability wave trains and wave packets produced by either receptivity or by artificial means to the point where the final breakdown to turbulence starts; (3) the development of a method for the prediction of transition based on stability theory and knowledge of external disturbances; and (4) passive and active methods of transition control. The research will encompass two- and three-dimensional incompressible, subsonic, transonic, supersonic and hypersonic boundary layers.

Propulsion and Power Research and Technology

W92-70005 **(22) 505-62**
Lewis Research Center, Cleveland, OH.
PROPULSION AND POWER RESEARCH AND TECHNOLOGY
J. A. Ziemianski 216-433-3901

The broad objective is to carry out propulsion research and

technology development at the discipline, component and subsystem levels that will lead to significant improvements in capability and efficiency. Advances in the propulsion systems of a variety of aircraft operating over a broad range of flight regimes will be pursued through an integrated program of in-house, contract and grant activities. In the subsonic regime, research is aimed at reducing the fuel consumption of small turbine engines for rotorcraft and commuters by 30 percent, improving the helicopter transmissions, and reducing the noise from high speed fans. Research in supersonic propulsion focuses on advanced concepts for STOVL, supersonic cruise and fighter/attack aircraft which include vectoring nozzles, the supersonic throughflow fan, variable geometry inlets and integrated flight/propulsion controls. Hypersonic technology for future hypersonic/transatmospheric flight vehicles with emphasis on air-breathing propulsion is provided. Two key tools will continue to be developed to enhance these research efforts: advanced computational methods for numerically modeling internal flows and non-intrusive measurement techniques.

W92-70006 **(23) 505-62**
Langley Research Center, Hampton, VA.
PROPULSION AND POWER RESEARCH AND TECHNOLOGY
R. V. Harris, Jr. 804-864-6048

Advanced experimental and analytical techniques are used to develop technology for airbreathing hypersonic propulsion concepts, to significantly improve the performance potential of hypersonic flight vehicles including an understanding of and solutions to problems inherent to such vehicles. In the area of high performance aircraft the program focus is on providing basic information on the effects of advanced propulsion concepts on the performance and interference characteristics of advanced aircraft. Analytical and experimental studies using advanced facilities and techniques are utilized to investigate scramjet engine components, complete subscale engines, fundamental flow problems inherent to such engines, and engine/airframe integration. Advanced aircraft configurations and generic models are used for investigations of thrust vectoring and reversing, 2-D nozzles, and propulsion control.

Materials and Structures Research and Technology

W92-70007 **(21) 505-63**
Ames Research Center, Moffett Field, CA.
MATERIALS AND STRUCTURES RESEARCH AND TECHNOLOGY
V. Michael DeAngelis 805-258-3921
(505-59-00; 506-43-00)

The objective is to provide the materials and structures research and technology necessary for significant improvements in the performance, durability, and economy of future generation aircraft. In the area of hypersonics, techniques for extreme temperature (cryogenic to 3500 F) testing of advanced structural concepts and materials will be developed and applied; advanced high temperature structural measurement systems will be developed; and analytical modeling techniques will be applied and evaluated. In the area of airframe materials and structures, analytical capability will be upgraded, and predictions will be correlated with measurements for the evaluation of aeroelastic computer analysis codes and to investigate new vehicle configurations. Codes will continue to be developed which simulate unsteady transonic flow with aeroelastic effects.

W92-70008 **(22) 505-63**
Lewis Research Center, Cleveland, OH.
MATERIALS AND STRUCTURES RESEARCH AND TECHNOLOGY
S. J. Grisaffe 216-433-3193
(510-01-00)

There two major objectives of this RTOP. The first is to advance the level of materials and processing technologies for high-temperature metallic, polymeric, and ceramic materials in order to contribute to improving the performance, life, reliability, structural efficiency, and/or to reducing the cost of future turbine engines (the prime emphasis of the work is directed toward developing greater understanding and modeling of the interrelationships among material composition/microstructure, fabrication processes, and mechanical/physical properties). The second major objective is to develop and verify advanced analysis and synthesis methods, advanced generic structural concepts,and advanced quantitative life prediction capabilities applicable to high temperature aerospace propulsion components. In addition, improved analytical methods to describe and predict the dynamic and aeroelastic response of aircraft turbine engine systems will be developed and experimentally validated. Emphasis will be on high temperature applications. Material behavior constitutive relations will be developed emphasizing anisotropy of metallic/ceramic/composite materials. Generic structural concepts will be conceived to exploit the capabilities of advanced material systems.

W92-70009 **(23) 505-63**
Langley Research Center, Hampton, VA.
MATERIALS AND STRUCTURES RESEARCH AND TECHNOLOGY
C. P. Blankenship 804-864-6005

This research includes executing analytical and experimental programs in structures, materials, and acoustics with emphasis on: (1) thermal structures, aeroelasticity, unsteady aerodynamics, and aeroservoelasticity; (2) structural mechanics and landing dynamics; (3) polymeric materials, metallic materials, and composite materials; (4) aeroacoustics and structural acoustics; (5) nondestructive evaluation of bonded fuselage structures and fatigue and fracture analysis for fuselage joints; and (6) interdisciplinary analysis and optimization. Principal research objectives include providing structures and materials technologies that will enhance the performance, efficiency, and reliability of advanced commercial, military, and general aviation aircraft. Analytical, computational, and experimental approaches are included in the fundamental research that is conducted in-house, by university grant, and under contract to industry.

Controls, Guidance, and Human Factors Research and Technology

W92-70010 **(21) 505-64**
Ames Research Center, Moffett Field, CA.
CONTROLS, GUIDANCE, AND HUMAN FACTORS RESEARCH AND TECHNOLOGY
J. A. Albers 415-604-5070
(505-68-00; 506-71-00; 533-02-00)

The objectives are to develop guidance, control, and crew/cockpit/air traffic control (ATC) interaction technologies to enable design of more effective civil and military aircraft and to ensure safe, efficient aircraft operations; and to perform computer science research to develop an understanding of the tradeoffs among algorithms, systems software, and architectures for

computational aeroscience applications. Research will be conducted on control systems for superaugmented aircraft as well as control, guidance, and display systems to achieve tactical path planning and more efficient ATC operations. Work will be done on the application of expert systems, computer vision, and guidance technology to enable automated rotorcraft flight in the nap-of-the-earth and maneuvering flight for fighter/attack aircraft. Human factors research will focus on understanding the tasks of piloting, air traffic control, and ground support operations in terms of the resources required from human capabilities; developing tools for the design and evaluation of crew/cockpit interfaces and operational procedures to support more effective crew performance; monitoring flight crew performance and assisting them in contingency operations, and improving aviation system reliability and precision. The approach will be to conduct analytic studies and evaluate concepts in flight simulation and in flight.

W92-70011 **(23) 505-64**
Langley Research Center, Hampton, VA.
CONTROLS, GUIDANCE AND HUMAN FACTORS RESEARCH AND TECHNOLOGY
J. F. Creedon 804-864-6033
(505-68-00)

This RTOP develops, validates and transfers to user communities, the advanced control, guidance and human factors research and technology needed for continued improvements to all weather operational performance, efficiency, safety, competiveness, and reliability of U.S. subsonic, supersonic, and hypersonic aircraft. Specific objectives include: development, validation, and demonstration of tools and methods for generating and evaluating reliable software and designing fault tolerant digital flight systems; multi-disciplinary efforts to develop and validate airborne windshear detection/avoidance techniques; application of advanced controls, displays and decision making aids to increase cockpit efficiency and enhance capacity of NAS; development of design methods for advanced high performance aircraft guidance and control systems; providing sensor technology for hypersonic aircraft; exploration of parallel computing system issues and evaluation of computer architectures; development and validation of models and crew performance measures for detection of pilot/crew workload and awareness state; and investigation of computing technologies to achieve large increases in performance. The approach taken includes establishing basic concepts and theories, developing and validating new concepts and innovative techniques through analysis, simulation, and laboratory testing, and finally, demonstration of most promising concepts in flight tests. Computer science research is augmented through the University of Illinois and LaRC sponsored ICASE.

W92-70012 **(51) 505-64**
Goddard Space Flight Center, Greenbelt, MD.
CONTROLS, GUIDANCE AND HUMAN FACTORS RESEARCH AND TECHNOLOGY
B. L. Shaw 804-824-1654

The objective of this RTOP is to provide appropriate support at the Wallops Flight Facility (WFF) for OAST programs and projects. Operational support includes: project coordination; airport maintenance and management; ADP; specialized instrumentation and other miscellaneous equipment; and contractual services for aircraft fuel operations, control tower operation, line service support, crash-fire-and-rescue standby, and miscellaneous shop support.

Flight Systems Research and Technology

W92-70013 **(21) 505-68**
Ames Research Center, Moffett Field, CA.
FLIGHT SYSTEMS RESEARCH AND TECHNOLOGY
D. H. Gatlin 805-258-3166
(533-02-00; 505-59-00)

The overall objective is to provide the necessary research and technology development of advanced flight systems for application to future military and civil aircraft. This includes the necessary supportive development of testing techniques and instrumentation to enhance data accuracy. Research will be conducted as part of the NASA High Angle-of-Attack Technology program. Flight test of the X-31 aircraft will also be conducted to validate integrated technologies and maneuver benefits. Flight experiments will be conducted using the High Alpha Research Vehicle (HARV) while full-scale wind-tunnel tests will be conducted in the National Full-scale Aerodynamic Complex (NFAC) for correlation with flight. Unconventional approaches for high alpha flight control and maneuvering will be investigated. Non-intrusive optical air data laser systems will be evaluated through a joint NASA/DARPA program focusing on the capabilities of the technology as a measurement technique in the flight environment. A modern set of testbed aircraft will be established to support NASA developed flight systems research experiments. High speed experiments will be conducted on the SR-71 aircraft.

W92-70014 **(22) 505-68**
Lewis Research Center, Cleveland, OH.
FLIGHT SYSTEMS RESEARCH AND TECHNOLOGY
J. A. Ziemianski 216-433-3901

The overall objective of this effort is to provide for the necessary research and technology development of advanced flight systems concepts for application to future military and civil aircraft. This part of the flight systems research and technology program is focused on advancing critical technology needed to solve propulsion and icing problems associated with operation of military and civil aircraft and propulsion and control problems associated with operation of military high performance STOVL aircraft. The current plans for this research area are to develop analytical and experimental simulation techniques to study aircraft icing problems and to develop advanced ice protection system concepts to improve aircraft productivity, operational capability and safety, and to identify and develop propulsion technology for supersonic STOVL aircraft.

W92-70015 **(23) 505-68**
Langley Research Center, Hampton, VA.
FLIGHT SYSTEMS RESEARCH AND TECHNOLOGY
R. V. Harris, Jr. 804-864-6048
(533-02-00)

The objectives are: to develop advanced methods and vehicle concepts needed to significantly increase fighter maneuverability considering the effects of high angle of attack, separated flow conditions, vortex flows, and thrust vectoring; and to utilize flight experiments to validate key elements.

Systems Analysis

W92-70016 **(21) 505-69**
Ames Research Center, Moffett Field, CA.
SYSTEMS ANALYSIS
G. H. Kidwell 415-604-5886

The primary objective is to provide key guidance information on advanced aircraft research, technology development and flight research programs. Efforts are structured to support the High-Speed Rotorcraft and the Generic Hypersonics programs. In addition, the flight research systems analysis, conducted at the Dryden Flight Research Facility, is focused on development of

selection criteria for the highest payoff flight research projects. Both in-house and contracted studies are undertaken to perform the technical evaluation and sensitivity analysis of fully integrated aircraft designs. In addition, in-house studies address unique applications of advanced technologies to investigate alternate configurations of baseline aircraft and to identify new vehicle concepts. A consequent area of investigation is the development of advanced design methodology. Non-empirical methods are being developed, in coordination with the Langley and Lewis Research Centers, to make fullest use of new technologies in aircraft design and to achieve improved analytical capabilities in sensitivity studies.

W92-70017 **(22) 505-69**
Lewis Research Center, Cleveland, OH.
SYSTEMS ANALYSIS
D. C. Mikkelson 216-433-7011
(537-01-00)

The fundamental objective is to perform design and sensitivity studies in areas of propulsion systems and propulsion integration in order to identify technology research opportunities, define vehicle requirements and provide support for programmatic decision making. Both in-house and contracted studies are conducted on a wide variety of engine cycles, propulsion systems and engine/airframe combinations in order to quantitatively evaluate performance and sensitivity parameters. Furthermore, advanced analytical and design methodology are being developed, in coordination with the Ames and Langley Research Centers, for improved accuracy and computational efficiency in an overall integrated propulsion/airframe analysis system.

W92-70018 **(23) 505-69**
Langley Research Center, Hampton, VA.
SYSTEMS ANALYSIS
R. V. Harris, Jr. 804-864-6048
(537-01-00)

The focus of this work is to provide information applicable to the guidance and planning of NASA's aeronautics research and technology programs. Vehicle classes being investigated include subsonic and supersonic commercial transports, high performance aircraft and hypersonic vehicles. In-house and contracted studies identify high payoff, emerging technology needs and opportunities that can lead significant advancements in future aircraft. Tradeoff analyses are conducted to optimize select parameters and to determine the sensitivity of a configuration to technology developments. Multidisciplinary methods development is conducted, in coordination with the Ames and Lewis Research Centers, to strengthen analytical capabilities and reduce turnaround times. Methods are being developed that will enhance multidisciplinary coupling in the conceptual design and optimization process.

Interdisciplinary Technology

W92-70019 **(21) 505-90**
Ames Research Center, Moffett Field, CA.
INTERDISCIPLINARY TECHNOLOGY
C. Smith 415-604-5113

The objective of this RTOP is to promote and maintain innovative, high-risk, university-based basic research in aeronautics through research and training grants, cooperative research efforts, and a joint research institute. The objective is accomplished through three elements within the RTOP: funds for Independent Research; Aeronautics Graduate Research Program; and a Joint University Institute. Funds for Independent Research support innovative and high-risk basic research in aeronautics, usually by means of unsolicited proposals from universities. The Aeronautics Graduate Research Program provides grants to support graduate training and research in aeronautics. A significant portion of the training will be through student research conducted at Ames Research Center. The Joint University Institute element provides core funding for the Ames/Stanford Joint Institute for Aeronautics and Acoustics (JIAA). The Institute promotes an active NASA/Stanford interchange to maintain cooperative, innovative advanced research in the disciplines of aeronautics and acoustics.

W92-70020 **(22) 505-90**
Lewis Research Center, Cleveland, OH.
INTERDISCIPLINARY TECHNOLOGY
M. E. Goldstein 216-433-5825

The overall objective is to originate, support, promote, and maintain innovative, high-risk, long-term, university-type research through research and training grants, cooperative research efforts, and joint research institutes and activities. The program allows the Office of Aeronautics and Space Technology (OAST) to initiate fundamental studies in areas not presently included in a specific discipline program and to sponsor graduate training in aeronautics. It is accomplished through four program elements: (1) Fund for Independent Research; (2) Graduate Program in Aeronautics; (3) Joint University Institutes; and (4) Lewis Research Academy. The Fund for Independent Research Supports novel, long-range, high-risk basic research activities at universities that are related to NASA's aeronautics activities. The Graduate Program in Aeronautics sponsors graduate training and research in areas that are relevant and acceptable to both NASA and the universities. The Joint University Institutes provide some of the core funding for the Ohio Aerospace Institute, whose objective is to expand Center involvement with the university community. The Lewis Research Academy consists of a core group of internationally recognized basic researchers under the general cognizance of the Chief Scientist. Its primary purpose is to ensure that present and future Lewis programs achieve the maximum benefit from Lewis basic research activities.

W92-70021 **(23) 505-90**
Langley Research Center, Hampton, VA.
INTERDISCIPLINARY TECHNOLOGY
M. F. Card 804-864-6062
(509-10-00)

The objective of this work is to originate, support, promote, and maintain innovative, high-risk, long-term university-based research through research and training grants, cooperative research efforts, and joint research institutes. This is accomplished through two program elements: (1) the Graduate Program in Aeronautics (GPA); and (2) Joint University Institutes (JUI), which includes the Joint Institute for Advancement of Flight Sciences (JIAFS) and the Institute for Computer Applications in Science and Engineering (ICASE). The approach is as follows: GPA sponsors graduate training and research that is relevant to both NASA and the University in the field of aeronautics and encourages a greater number of newly graduating U.S. citizen engineers to pursue graduate training. A significant portion of the training will be through student research conducted with faculty support at a NASA Center using NASA facilities. The JUI provides a core level of funding for the promotion of an active NASA/university interchange in order to maintain cooperative, innovative, venture research at the leading edge of the latest technology and techniques in science, engineering, mathematics, and computers.

Aeronautics Systems Technology Programs

High-Performance Computing

W92-70022 **(21) 509-10**
Ames Research Center, Moffett Field, CA.
COMPUTATIONAL AEROSCIENCES
F. R. Bailey 415-604-5065

The objective is to support computational aerosciences by

developing an understanding of the relationships and tradeoffs between algorithms, systems software, and computer architectures for these applications. Approaches, techniques, and tools are needed to apply this insight to the development of optimal hardware/software systems for this class of problems. The research will permit better utilization of emerging concurrent processors, and will influence the design of computer systems crucial to NASA in the 1990's. This RTOP is a response to the Office of Science and Technology Policy's (OSTP's) Federal High Performance Computing and Communications Program. This research will bring together computer science and computational physics expertise to analyze the requirements for multidisciplinary computational aeroscience, evaluate extant concepts and products, and conduct the necessary research and development. The steps involved include: the development of requirements and evaluation of promising systems concepts using multidisciplinary algorithms; the development of techniques to validate system concepts; the building of application prototypes to serve as proof of concept; and the establishment of scalable testbed systems which are connected by multimegabit/second networks.

W92-70023 **(22) 509-10**
Lewis Research Center, Cleveland, OH.
COMPUTATIONAL AEROSCIENCES
L. D. Nichols 216-433-3213
(505-62-00; 506-63-00)

The objective of this work is to develop and demonstrate high performance computing techniques that will enable the integrated, multidisciplinary simulation, analysis and optimization of aerospace propulsion system designs. Methodologies will be developed for numerically simulating the time-dependent physics of interacting propulsion components and entire systems. Resulting models, algorithms, and codes will be implemented on scalable, massively parallel architecture computers. Advanced system software will be developed to provide users with an easy-to-use computational environment for propulsion simulation and analysis. Simulation testbeds will be established to support the development and testing of the required hardware and software.

W92-70024 **(23) 509-10**
Langley Research Center, Hampton, VA.
COMPUTATIONAL AEROSCIENCES
R. V. Harris, Jr. 804-864-6048

As part of the High Performance Computing and Communications Program, the goal of the Computational Aeroscience (CAS) Project at NASA LaRC is to develop necessary computational technology for the numerical simulation of complete aerospace vehicles for both design optimization and analysis throughout the flight envelope. The goal is supported by four specific objectives: (1) to develop multidisciplinary computational models and methods for scalable, parallel computing systems; (2) to accelerate the development of computing system hardware and software technologies capable of sustaining teraFLOPS performance level on computational aeroscience applications; (3) to demonstrate and evaluate computational methods and computer system technologies for selected aerospace vehicle and propulsion systems models on scalable, parallel computing systems; and (4) to transfer computational methods and computer systems technologies to aerospace and computer industries. The general strategy of the project is to achieve understanding of all aspects of complete future implementations of CAS grand challenge applications on fully-scaled teraFLOPS computing systems through a series of controlled limited-scope experiments utilizing grand challenge based subproblems and test cases. The CAS project at LaRC will focus on a high speed civil transport (HSCT).

W92-70025 **(21) 509-20**
Ames Research Center, Moffett Field, CA.
EARTH AND SPACE SCIENCES
K. G. Stevens, Jr. 415-604-5949

The objective is to support the Earth and Space Science Project of the NASA High Performance Computing and Communication Program (HPCCP) by establishing high speed data communications between Goddard Space Flight Center, the National Research and Education Network (NREN), and other NASA centers participating in HPCCP. This RTOP is a response to the Office of Science and Technology Policy's (OSTP's) Federal High Performance Computing and Communications Program. This research will begin by providing NASA access to the interim NREN. The initial communications will be at 45 megabits per second and research will be conducted to permit this speed to be increased to the multiple gigabit range. These networks will be used to interconnect the NASA high performance computing testbeds and to interconnect NASA to the larger national community.

W92-70026 **(51) 509-20**
Goddard Space Flight Center, Greenbelt, MD.
EARTH AND SPACE SCIENCES
Jan M. Hollis 301-286-7591

The goal of this RTOP is to accelerate the development and application of high performance computing technologies to meet the Grand Challenge computational needs of the U.S. Earth and space science community. This goal is supported by three specific objectives: (1) development of algorithms and architecture testbeds capable of fully utilizing massively-parallel concepts and scalable to sustained teraFLOPS performance; (2) creation of a generalized software environment for massively parallel computing applications; and (3) demonstration of the impact of these technologies on NASA research in Earth and space sciences physical phenomena.

W92-70027 **(55) 509-20**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
EARTH AND SPACE SCIENCES
J. E. Patterson 818-354-8332
(505-65-00; 506-44-00; 590-32-00; 591-11-00; 509-30-00)

The objective of this effort is to establish a Multiple-Instruction Multiple-Data (MIMD) parallel processor testbed at JPL which will host MIMD applications developed for the NASA High Performance Computing and Communication (HPCC) Program, Earth and Space Science (ESS) Project. These applications include multi-disciplinary modeling of Earth and space phenomena and analysis of data from remote sensing instruments. Included in the establishment of a MIMD environment is the development of system software and user tools to support application developers. The JPL ESS MIMD Testbed will be established either by procuring a new system or by augmenting an existing one. Within the first few months of this effort a survey of potential systems and augmentations will be made. Software will be developed to assist applications developers. These software include decomposition tools, performance monitors, and tools for solving partial differential equations such as parallel mesh generation and partitioners. Where appropriate and available, software will be procured which will aid in applications development.

W92-70028 **(55) 509-30**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
REMOTE EXPLORATION AND EXPERIMENTATION
John M. Davidson 818-354-7508
(505-65-00; 506-44-00; 590-32-00; 591-11-00)

The Remote Exploration and Experimentation (REE) Project will demonstrate the practicality and utility of high performance computing in space. This goal is supported by two specific objectives: (1) the demonstration to flight projects that a thousand-fold increase in flight computer system performance over that of current single processor systems is feasible, desirable,

and possesses a solid engineering path from functional prototype to flight; and (2) the identification and demonstration of a parallel, scalable architecture which can incorporate new technologies, meet a broad range of requirements, and provide affordable fault tolerance and long-term reliability in an environment of limited power and weight, high radiation, and no accessibility for repair. The approach taken to achieve these objectives has two major elements: (1) two grand challenge applications will be chosen as test cases to direct and validate architectural research; and one of these will typify spaceborne computing tasks requiring data analysis while the other will typify tasks requiring adaptive decision making; and (2) a scalable emulation testbed will be developed and used to evaluate architectural concepts. A major part of this evaluation will involve simulations and demonstrations of the selected applications. The REE Project will be in its definition phase in FY-92.

Materials and Structures Systems Technology

W92-70029 **(22) 510-01**
Lewis Research Center, Cleveland, OH.
ADVANCED HIGH-TEMPERATURE ENGINE MATERIALS TECHNOLOGY
H. R. Gray 216-433-3230
(505-63-00)

The major objective of this RTOP is to develop the technology for revolutionary advances in materials to enable the development of 21st century subsonic transport aircraft propulsion systems having greatly decreased specific fuel consumption, reduced direct operating costs, improved reliability, and extended life. To accomplish this objective very high temperature, lightweight material systems and the associated processing technologies will be developed. This includes the development of advanced metals, fibers, and intermetallic matrix composites; advanced ceramic fibers and ceramic matrix composites; and advanced polymeric matrix composites. Advanced analysis, design methods, and life prediction methodologies will also be developed to support the use of these materials in advanced turbine engines. Generic propulsion system structural concepts will be used to evaluate the advanced materials and determine the validity of structural analysis methodologies developed under the program.

W92-70030 **(22) 510-02**
Lewis Research Center, Cleveland, OH.
ADVANCED COMPOSITE MATERIALS TECHNOLOGY
C. C. Chamis 216-433-3252
505-63-00; 590-21-00)

The major objective of the Advanced Composites Technology RTOP is to develop an integrated technology base that provides impetus for cost effective use of advanced composite materials in the primary structures of future aircraft. Included in this is the development of a solid structural mechanics technology base that provides the scientific understanding of failure mechanisms and establishes true limits of performance so that design and analysis procedures may be applied to the primary structures. The research includes application of probabilistic analysis methods to predict the uncertainties in the response, fracture, durability and life of composite structures. The research also includes the development of a validated and verified computer code to computationally simulate composite structures for assured reliability and risk.

W92-70031 **(23) 510-02**
Langley Research Center, Hampton, VA.
ADVANCED COMPOSITE MATERIALS TECHNOLOGY
C. P. Blankenship 804-864-6005

The research includes advanced concept development, analysis, fabrication, testing, and demonstration programs in composite structures and materials with emphasis on primary structure for aircraft applications. The benefits of advanced composites will be exploited to develop enabling technology and required scientific basis for verified innovative lightweight, structurally efficient, damage tolerant, and cost effective materials and structural concepts. Innovative concepts will be developed and demonstrated for use in future primary aircraft structures. A multidisciplinary approach will be utilized involving advanced organic matrix materials, cost effective fabrication techniques, innovative structural concepts, damage tolerant designs, and fatigue/fracture characterization to promote new material concepts that are integrated with structures technology. Structural mechanics technologies will be developed including analysis, design, and test methods for wing and fuselage components and subcomponents subjected to realistic loadings.

Rotorcraft Systems Technology

W92-70032 **(21) 532-06**
Ames Research Center, Moffett Field, CA.
ADVANCED ROTORCRAFT TECHNOLOGY
W. Snyder 415-604-6570
(505-61-51; 505-59-36)

The objective of this program is to advance rotorcraft systems technology for reduced noise and for high subsonic speeds to enable advances in military and civil rotorcraft vehicles. Rotorcraft noise methodology will be improved by the acquisition of a modern airloads data base and the refinement of predictive methods. Semi-empirical design methods will be improved and analytical and Computational Fluid Dynamics (CFD) codes will be validated. Scaling laws will be investigated by comparison of small and large scale model data with flight test data. Analytical capabilities, ground based facilities and flight research vehicles will be used to advance technology for high speed rotorcraft. Technology requirements for civil applications of the tiltrotor will focus on noise reduction. Both design improvement and noise abatement procedures will be investigated.

W92-70033 **(23) 532-06**
Langley Research Center, Hampton, VA.
ADVANCED ROTORCRAFT TECHNOLOGY
C. P. Blankenship 804-864-6005
(505-63-00)

The objective is to develop the technology for improving rotor noise prediction methodology, noise design criteria, and noise reduction methodology for current and future high speed rotorcraft. The approach is to acquire acoustic data from tests of a variety of rotor and rotor system configurations and to utilize these data to develop and verify advanced noise prediction methods as well as innovative noise reduction concepts. The research is performed through contracts with major U.S. manufacturers and is coordinated with NASA in-house aeroacoustics research and with company independent research. For tiltrotor technology the focus will be gathering noise flight test data and preparing for detailed wind tunnel tests. The data will be used to verify tiltrotor-versions of the rotor noise codes mentioned above.

High-Performance Aircraft Systems Technology

W92-70034 **(21) 533-02**
Ames Research Center, Moffett Field, CA.
HIGH-PERFORMANCE FLIGHT RESEARCH
M. R. Barber 805-258-3179
(505-68-00; 505-63-00)

Generic high angle of attack research will be continued with an F-18 test aircraft. Envelope expansion with the thrust vectoring control system will be completed. Under NASA/USAF Advanced Fighter Technology Integration (AFTI) Program, the F-16 will continue Close Air Support (CAS) technology development. The F-15 Performance Seeking Control (PSC) Program will conduct single engine flight testing, to be followed by a design and development effort to optimize the total integrated propulsion and flight control systems for two engine full envelope operation. Integrated flight/propulsion control techniques will be investigated to minimize the impact of aircraft flight control failures. The modified YAV-8B Harrier will be used to validate design methodologies for integrated flight and propulsion controls and develop design criteria for advanced STOVL aircraft. The X-29 Forward Swept Wing will be completed with completion of final reports. Final analysis and reporting of the results of the flight phase of the Supersonic Laminar Flow experiment on F-16 XL Ship 1 will be initiated in FY-91. A separate Supersonic Laminar Flow flight experiment will be initiated on F-16XL Ship 2 following flight evaluation of the baseline aircraft and engine.

W92-70035 **(22) 533-02**
Lewis Research Center, Cleveland, OH.
HIGH-PERFORMANCE FLIGHT RESEARCH
Peter G. Batterton 216-433-3912
(505-68-00; 505-62-00)

Generic high angle of attack research will be conducted with an F-18 test aircraft. Of particular interest are the effects of high air flow angles due to aircraft maneuvers and the interaction with the aircraft forebody, the resulting flow field as ingested by the inlet system, and the response of the inlet to such flow fields. The objective is to use results of the aircraft experiments to correlate wind tunnel and Computational Fluid Dynamics (CFD) analyses.

W92-70036 **(23) 533-02**
Langley Research Center, Hampton, VA.
HIGH-PERFORMANCE FLIGHT RESEARCH
R. V. Harris, Jr. 804-864-6048
(505-68-00)

The objective of this RTOP is to provide improved design methods for highly maneuverable aircraft in the areas of aerodynamic performance, stability, and control with emphasis on moderate and high angles of attack. More specifically, work will be focused on validation/demonstration of high angle of attack aerodynamics technology applicable to fighter airplanes. The approach to be used will combine full scale flight and wind tunnel testing. The focus on high angle of attack technology validation will be the NASA F-18 High-Alpha Research Vehicle (HARV) at NASA-Dryden. This program involving Ames, Dryden, LeRC, and LaRC, is concentrating on the analysis, prediction, and control of the separated vortex flows generated by the fuselage forebody and wing-body strakes at high angles of attack.

Advanced Propulsion Systems Technology

W92-70037 **(22) 535-03**
Lewis Research Center, Cleveland, OH.
ADVANCED TURBOPROP SYSTEMS
J. A. Ziemianski 216-433-3901

The objective of the Advanced Turboprop Systems effort is to develop and evaluate propeller technologies critical for reduction of engine source noise and to the efficient, reliable, and acceptable operation of future subsonic transport aircraft. Both single- and counter-rotating propeller technologies for ducted and unducted configurations are being evaluated. Propeller technologies will be evaluated in ground tests of scale model hardware in both the unducted and ducted configurations. Aerodynamic, acoustic and mechanical performance will be evaluated.

W92-70038 **(23) 535-03**
Langley Research Center, Hampton, VA.
ADVANCED TURBOPROP SYSTEMS
C. P. Blankenship 804-864-6005

The objective of the program is to develop both aerodynamic and acoustic technology necessary for the design of future advanced turboprop/ducted fan/unducted fan powered aircraft. Configurations of interest are powered by highly loaded, multibladed, single-rotating and counter-rotating propeller systems and large ducted fan systems. Emphasis is on prediction and control of propeller/fan source noise and engine/airframe aerodynamic interactions. The approach is to develop improved analytical and experimental methods for predicting aerodynamic flow field interactions, aircraft stability and control characteristics, propeller noise (both in the near field and far field), and airborne and structure-borne noise transmission through the cabin sidewall. The prediction methods are validated using wind tunnel data and results from a joint NASA/Industry flight demonstration program. The improved prediction methods and criteria will be used to guide the design of advanced turboprop/unducted fan propellers, ducted fans, and aircraft configurations.

W92-70039 **(22) 535-05**
Lewis Research Center, Cleveland, OH.
GENERAL AVIATION/COMMUTER ENGINE TECHNOLOGY
J. A. Ziemianski 216-433-3901

The objective of this effort is to provide the advanced technology base needed to insure the technical advantage of U.S. manufacturers in the future small turbine engine marketplace. The approach is to evolve, evaluate, and verify critical advanced technology applicable to gas turbine engines of 250 to 5,000 shp suitable for general aviation, commuter, rotorcraft, and cruise missile applications. Analytical and experimental studies will emphasize revolutionary powerplant improvements in the 250 to 1,500+ shp range. This approach will provide industry with the capability to design and build small engines with performance, maintainability, and durability approaching that of large engines. The technology involved, while primarily applicable to small engines, is also applicable to higher thrust engines. This is especially true for very high pressure ratio engines (to 100 atm) which will approach the smaller engines in geometrical size.

Numerical Aerodynamic Simulation

W92-70040 **(21) 536-01**
Ames Research Center, Moffett Field, CA.
NUMERICAL AERODYNAMIC SIMULATION (NAS)
D. Cooper 415-604-4500
(536-02-00)

The objectives of this NAS Program are threefold: to act as the pathfinder in advanced, large scale computer system capability through hardware and software technologies and through creation of an applied computer science research effort; to provide a

National computational capability to NASA, DOD, other Government agencies, universities and industry in order to ensure continuing U.S. leadership in computational fluid dynamics and related disciplines; and to provide a powerful research tool for the NASA Office of Aeronautics and Space Technology. The NAS Program is composed of four elements: the computer processing system (the NAS Processing System Network or NPSN); the facility to house the associated machines and people; the operation of the NPSN; and an applied research effort in high performance computing architectures, algorithms and systems technology. This RTOP covers the overall management of the Program, the facility, the development of the processing system and computational system research. The NPSN technical approach is one of phased and evolutionary development incorporating the latest advancements in scientific supercomputers, graphics devices, storage media and other computer system technologies.

W92-70041 **(21) 536-02**
Ames Research Center, Moffett Field, CA.
NUMERICAL AERODYNAMIC SIMULATION (NAS) OPERATIONS
D. Cooper 415-604-4500
(536-01-00)

The objectives of the NAS Program are threefold: to act as the pathfinder in advanced, large scale computer system capability through systematic incorporation of state of the art improvements in computer hardware and software technologies; to provide a National computational capability to NASA, DOD, other Government agencies, universities and industry in order to ensure continuing U.S. leadership in computational fluid dynamics and related disciplines; and to provide a powerful research tool for the NASA Office of Aeronautics and Space Technology. The NAS Program is composed of four elements: the computer processing system (the NAS Processing System Network or NPSN); the facility to house the associated machines and people; the operation of the NPSN; and an applied research effort in high performance computing architectures, algorithms and systems technology. This RTOP covers the operations elements of the NAS Program. It does not cover the overall management of the Program, the facility and development of the processing system which is covered in related RTOP 536-01.

High-Speed Research

W92-70042 **(21) 537-01**
Ames Research Center, Moffett Field, CA.
ATMOSPHERIC EFFECTS
R. Kurkowski 415-604-6569
(537-02-00; 537-03-00)

The objectives are to provide a continually updated information base for advanced planning, long term guidance, and direction to High Speed Civil Transport (HSCT) research and technology programs performed by NASA and the U.S. commercial transport industry. The approach is to investigate the interdisciplinary design issues associated with HSCT aircraft using an Ames developed aircraft synthesis program, ACSYNT, which includes an economic analysis module, and enhancements as required, to enable the analysis of propulsion/airframe integration concerns, community noise and sonic boom characteristics on economic viability.

W92-70043 **(22) 537-01**
Lewis Research Center, Cleveland, OH.
ATMOSPHERIC EFFECTS
L. H. Fishbach 216-433-7020
(505-69-00; 537-02-00; 537-03-00)

Propulsion system studies will be performed to identify the most promising engine and noise suppression concepts/ technologies for an High Speed Civil Transport (HSCT). The economic penalties associated with satisfying projected environmental constraints will also be determined. A spectrum of novel propulsion system concepts and technologies will be investigated in sufficient depth to identify preferred engine types and optimum cycle parameters to minimize the adverse effects of complying with expected airport noise and cruise emission constraints. Key technology needs will be identified as well as associated benefits. Five engine types (Turbine Bypass Engine (TBE), MFTF, Variable Cycle Engine (VCE), Flade, and TBE/IFV) and several noise suppression concepts will be comparatively assessed to determine which combination is the most promising for the HSCT application. After preliminary screening analyses by the engine companies and NASA, airframe manufacturers will perform a final assessment via a flyoff analysis to help downselect to two inlet/engine/nozzle systems.

W92-70044 **(23) 537-01**
Langley Research Center, Hampton, VA.
ATMOSPHERIC EFFECTS
R. V. Harris, Jr. 804-864-6048
(505-69-00; 537-02-00; 537-03-00)

The overall objective of this work is to provide guidance and direction to aeronautics/propulsion research and technical programs by NASA and the Nation's aviation industry to assure that any future fleet of High Speed Civil Transports (HSCT's) would not have a detrimental effect on the Earth's atmosphere. The best available atmospheric models will be improved and used to assess the effects of a projected fleet of HSCT's on global ozone, stratospheric climatology, and the stratospheric-tropospheric radiative balance. An oversight committee of experts in the field will review the research which can ultimately provide guidance for acceptable emissions budget and/or flight altitudes. Aircraft systems studies will be conducted to determine the viability of technological solutions for environmental concerns and to identify high payoff technology developments that will lead to an environmentally acceptable and economically viable HSCT. Technical solutions for various environmental concerns will be combined to determine the synergistic effects on the aircraft operational characteristics. Aircraft operational methods and/or flight paths will be developed to enhance environmental compatibility. The studies will provide necessary inputs to assess community noise and sonic boom levels, and also provide valuable guidance to the discipline specialist in selecting the most promising solution or combination of solutions.

W92-70045 **(21) 537-02**
Ames Research Center, Moffett Field, CA.
EMISSIONS AND SOURCE NOISE
R. Kurkowski 415-604-6569
(537-01-00; 537-03-00)

Three areas relating to the High Speed Civil Transport (HSCT) are addressed: low emission combustion; jet noise reduction; and nacelle airframe integration. The objectives for these three areas are to: develop NOx control technologies such that NOx production levels will be in the 3 to 8 g/kg (Emission Index) range; develop high speed jet noise reduction technology and concepts which would allow future HSCT's to comply with FAR Part 36 - Stage III noise levels, and; investigate the acoustical, internal performance and stability characteristics of candidate inlet systems for HSCT aircraft. The approach for combustion analyses includes the development and use of advanced computation methods and codes to model the reacting turbulent flow in candidate combustor configurations. Emphasis will be given to the computational chemistry determination of the chemical kinetics and thermodynamic database required to accurately model the flow. The approach to reduce high speed jet noise will be to develop and verify advanced aerodynamic analyses and noise prediction capabilities through higher fidelity computational models and controlled laboratory experiments using the 40 x 80 foot wind tunnel and advanced flow field measurements. Also, working with other Centers and industry, develop and conduct Computational

Fluid Dynamics (CFD) analysis and experimental program to study nacelle airframe integration, inlet stability, and acoustics.

W92-70046 **(22) 537-02**
Lewis Research Center, Cleveland, OH.
EMISSIONS AND SOURCE NOISE
E. J. Graber 216-433-5900
(537-01-00; 537-03-00)

The overall objective of this effort is to explore advanced concepts in propulsion emissions and noise reduction, and develop engine component technology for future supersonic transports leading to no harmful impact on the atmosphere and compliance with Federal Aviation Regulation 36 Stage 3 noise levels. The overall approach is to first develop and validate the required computational prediction codes using existing analysis tools wherever appropriate. Small scale laboratory and wind tunnel experiments will be conducted to improve the understanding of the key physics of both the noise and emissions problems and to provide code calibration/validation data. Wind tunnel tests of subscale nozzle configurations will then be conducted to demonstrate acceptable aerodynamic and acoustic performance across the take-off/transonic cruise performance range. Combustor subcomponent tests will be conducted and followed by rig tests of prototype combustor configurations to demonstrate acceptable NOx emissions levels and combustor efficiency.

W92-70047 **(23) 537-02**
Langley Research Center, Hampton, VA.
EMISSIONS AND SOURCE NOISE
C. P. Blankenship 804-864-6005
(537-03-00; 505-59-00)

The objective of this research is to develop an advanced and validated base of supersonic jet noise reduction technology for application to future civil supersonic transports. The goal is technology to support an economically viable transport compliant with Federal Air Regulation 36, Stage 3. Analytical, computational, and experimental approaches are included in research that is conducted in-house and by grant and contract. Improved understanding of the physical mechanisms by which supersonic flows generate noise is sought, and theories and validating data bases for accurate noise prediction and reduction are developed. The experimental portion of the program emphasizes model scale laboratory studies under controlled conditions.

W92-70048 **(21) 537-03**
Ames Research Center, Moffett Field, CA.
HIGH SPEED RESEARCH - COMMUNITY NOISE AND SONIC BOOM
R. Kurkowski 415-604-6569
(537-01-00; 537-02-00)

The objective is to develop the design methodology to reduce community noise (i.e., takeoff and approach noise) of High Speed Civil Transport aircraft to Federal Aviation Regulation (FAR) 36 III levels and to minimize the sonic boom impact. In a supporting area, the practical implementation of laminar flow control on highly swept wings at supersonic speeds offers the potential for significant reductions in cruise drag, thereby decreasing engine thrust requirements, sonic boom, and atmospheric effects. The approach for community noise reduction involves the development of accurate system noise prediction methodologies for supersonic transport aircraft, optimized engine placement for minimum noise impact, and efficient, low speed, high lift systems. In the sonic boom area, the research will concentrate on the development of low boom concepts and predictive methodology utilizing Computational Fluid Dynamics (CFD). Supersonic laminar flow control research involving ground-based facilities in addition to the F-16XL aircraft will be conducted to provide the technology base, including design criteria and predictive technology for the practical implementation of laminar flow control techniques.

W92-70049 **(23) 537-03**
Langley Research Center, Hampton, VA.
COMMUNITY NOISE AND SONIC BOOM
R. V. Harris, Jr. 804-864-6048
(537-01-00; 537-02-00)

The objectives are to provide understanding, innovative concepts, predictive capability, and minimization methodology for the acoustic disturbances and sonic boom generated by the operation of a High Speed Civil Transport (HSCT). An HSCT must be compliant with the intent of FAR 36 Stage III noise rules to be allowed to takeoff and land at existing international airports. Meeting community noise rules will most likely impose the severest weight and efficiency penalties of the environmental concerns. Validated noise prediction and suppressor technology will be developed as well as improved high lift systems to enable flight path optimization. Sonic boom prediction, propagation, minimization, and human perception must be better understood. Research to minimize the impact of the sonic boom signature by shaping and an assessment of public reaction to different types and amplitudes of sonic booms will establish the feasibility of supersonic overland flight. Methods that predict the effect of aircraft maneuvering, sonic boom focusing, and secondary booms will be developed. A flight experiment and accompanying transition prediction and design methodology will develop and validate technology for practical, reliable, and maintainable supersonic laminar flow control concepts for HSCT application. Laminar flow control offers the potential to dramatically reduce the takeoff gross weight by increasing vehicle efficiency and thus reduce the magnitude of environmental effects, as well as increase the economic viability of HSCT's.

W92-70050 **(22) 537-04**
Lewis Research Center, Cleveland, OH.
ENABLING PROPULSION MATERIALS
J. R. Stephens 216-433-3195
(510-01-00)

The objective of this RTOP is in cooperation with U.S. industry, to develop and demonstrate by 1999 the technical feasibility of high temperature, light weight composites for critical components of gas turbine engines so that an economically viable and environmentally acceptable high speed civil transport (HSCT) can be introduced into service by the year 2005. To accomplish this objective a major contractual effort augmented by in-house research will be undertaken over a seven year period. Major emphasis will be on two engine components, the combustor and the exhaust nozzle. Research and development will focus on ceramic matrix composites for the combustor and intermetallic, metal and ceramic matrix composites for the nozzle. Long term durability at extremely high temperatures will require research on fibers and fiber coatings; environmental durability; life prediction; failure analysis; composite fabrication; and joining technology. Component design-material property trade-off studies will guide the research and development efforts.

Advanced Subsonic Technology

W92-70051 **(22) 538-01**
Lewis Research Center, Cleveland, OH.
FLY-BY-LIGHT/POWER-BY-WIRE
Norman C. Wenger 216-433-3730
(505-62-50)

The overall objective of the program is to develop the technology base necessary for the confident application of integrated fly-by-light (FBL) and power-by-wire (PBW) systems to transport aircraft. Fly-by-light propulsion/flight control system technology will be advanced through research in electro-optic architectures and fiber optic sensors. The systems developed will be demonstrated through active (closed loop) ground and flight

tests. Power-by-wire technology research will focus on the development of an integral starter/generator, an advanced power management and distribution system, and electro-mechanical actuators (EMA). The full system will be ground tested and the EMA's flight demonstrated as an integral part of the active control system.

W92-70052 **(23) 538-01**
Langley Research Center, Hampton, VA.
FLY-BY-LIGHT/POWER-BY-WIRE
J. F. Creedon 804-864-6033
(505-64-00)

The goal of the program is to develop the technology base for confident application of integrated Fly-By-Light/Power-By-Wire (FBL/PBW) systems to transport aircraft. This is a joint NASA Langley and Lewis Research Center program. Lewis Research Center objectives are to develop and flight test: optical sensors and electro-optical converters, power management and distribution system, and electromechanical actuators. Langley Research Center objectives are to demonstrate architecture design and validation appropriate for certification of FBL/PBW systems; develop validated analytical and experimental assessment methodologies for electromagnetic environment effects; and integrate/demonstrate end-to-end FBL/PBW systems.

W92-70053 **(23) 538-02**
Langley Research Center, Hampton, VA.
AGING AIRCRAFT
C. P. Blankenship 804-864-6005
(505-63-00)

The goal of the Aging Aircraft program is to provide the technology that will enhance the structural integrity of commercial aircraft. This will be accomplished by integrating the disciplines of fracture mechanics, structural mechanics, and Non-Destructive Inspection (NDE) to develop an advanced technology which can be used to ensure the safe and economic operation of properly designed, constructed, and maintained commercial aircraft. The specific objectives of the program are as follows: (1) develop and verify advanced NDE technology that can reliably and economically detect disbonds, fatigue cracks, and corrosion of airframe structures; and (2) develop and verify advanced mechanics based prediction methodology which can be used to determine in-service inspection intervals, quantitatively evaluate inspection findings, and design and certify structural repairs. These research objectives will be accomplished through combined in-house, contracts, and grant activities. To facilitate technology transfer, the program will be conducted in full cooperation with the U.S. Airframe Manufacturers and Airline Operators.

Space Research and Technology Base

Aerothermodynamics Research and Technology

W92-70054 **(21) 506-40**
Ames Research Center, Moffett Field, CA.
AEROTHERMODYNAMICS RESEARCH AND TECHNOLOGY
J. O. Arnold 415-604-5265
(505-59-00; 506-43-00; 763-21-00)

The objective is to advance the fundamental understanding of aerodynamic flows in hypersonic flight regimes and to develop the codes to permit performance optimization of future aerospace vehicles. These include Aeroassisted Space Transfer Vehicles (Lunar and Mars) for the SEI and air-breathing NASP derived vehicles. Advanced computation methods and computer codes will be developed and validated for numerically simulating vehicle flow fields and then used to predict thermal loads and aerodynamic performance of the vehicle. The codes will yield solutions for the full Navier-Stokes equations for chemically reacting and radiating gases. Real gas properties, reaction rate constants, radiative transition probabilities and high-temperature transport properties will be determined from computational chemistry methods. Such developments depend on results of both numerical simulations and experiments for improving and/or validating these complex codes. Experimental research of thermochemical nonequilibrium processes will be performed to provide a database and to develop an understanding of coupled rotation-vibration-dissociation phenomena and nonequilibrium radiation in high enthalpy, hyper-velocity flows. Research for future experimental ground based facilities to study real-gas hypersonic flows will be conducted. Candidates for study are an advanced ballistic range and arc-driven hypersonic wind tunnels.

W92-70055 **(23) 506-40**
Langley Research Center, Hampton, VA.
AEROTHERMODYNAMICS RESEARCH AND TECHNOLOGY
W. Ray Hook 804-864-6055
(506-48-00; 506-49-00; 591-42-00)

This research is to improve the fundamental understanding of aerodynamic and aerothermodynamic flow phenomena over ascent, entry, and aerobraking vehicles and to develop the predictive capability to permit performance optimization of advanced aerospace vehicles. Emphasis is on providing flow-field computational techniques; providing real-gas chemistry models; utilizing wind tunnel, flight, and analytical prediction data to validate techniques for the design of future vehicles; providing the design and performance parameters on advanced vehicles to identify and analyze high payoff technologies; scoping convecting and radiative heating problems on advanced concepts and developing prediction techniques; providing the experimental and analytical data base to improve understanding of real-gas chemistry, Mach number, and Reynolds number on current and advanced vehicles; and improving wind-tunnel technology, test techniques, and instrumentation for fundamental research. Results will enhance the capabilities, reliability, versatility, and efficiency of future aerospace vehicles. Analytical, computational, and experimental techniques are included in the fundamental research conducted in-house, by university grants, and under contract to industry. The experimental portion of the program emphasizes and utilizes the unique capabilities of the Langley Hypersonic Facilities Complex and the 8-Foot High Temperature Tunnel. The theoretical program requires extensive use of current super computers and parallel computers and utilization of future computer technology.

Space Energy Conversion Research and Technology

W92-70056 **(22) 506-41**
Lewis Research Center, Cleveland, OH.
SPACE ENERGY CONVERSION RESEARCH AND TECHNOLOGY
H. W. Brandhorst 216-433-6149

The objective of this work is to provide a research and technology development base leading to a spectrum of advanced space power systems and subsystems. Both generic and NASA specific missions guide systems level analyses which identify technological options with maximum system leverage/impact. The research generally aims at providing the technological base for emerging ten-to-hundred kilowatt and ultimately to megawatt level power system needs, while also recognizing and addressing agency and other needs up to the ten kilowatt level. Areas include

photovoltaics, electrochemical energy storage, fault tolerant power management and distribution components and subsystems, spacecraft environmental interactions, integrated spacecraft bus technology, solar thermal and dynamic systems, advanced radiator concepts and surfaces, thermal control of advanced power electronics, and supporting technology for the SP-100 nuclear power system. Major thrusts are to improve performance, reliability and tolerance to the atomic oxygen, plasma and radiation environment while reducing cost and mass, where appropriate, for systems operating in the LEO, GEO and planetary environments.

W92-70057 **(23) 506-41**
Langley Research Center, Hampton, VA.
SPACE ENERGY CONVERSION RESEARCH AND TECHNOLOGY
W. Ray Hook 804-864-6055

This research, part of the Power Management Program, includes technology development for remote space-power distribution and studies. The objective is to develop key technologies for space-based and surface-based, laser-beamed-power transmission, in support of Space Exploration Initiative (SEI) missions, for electric-power distribution and propulsion. Solar-powered laser oscillators and amplifiers are conceived, tested, and modeled. The near-term goals are to define efficient, solar-powered lasers and to establish scaling laws for extrapolating to high-average-power operation. Experimental research and modeling define and develop large-scale, coherent combinations of electrically driven diode lasers. In conjunction with laser-energy generation, laser-to-electric conversion is a major aspect of laser transmission for electric power distribution. Laser photovoltaic conversion is being studied as a high-efficiency concept. Both experimental and theoretical research on this concept is directed toward efficient conversion of potential beamed-power wavelengths in the near infrared. To assess the advantages of space-power transmission and to guide the laser and converter research, limited trade and application studies are performed.

W92-70058 **(51) 506-41**
Goddard Space Flight Center, Greenbelt, MD.
SPACE ENERGY CONVERSION RESEARCH AND TECHNOLOGY
R. McIntosh 301-286-3478

The principal objective of this research is to develop, analyze, and test advanced thermal energy management concepts and components for application to future spacecraft and space facilities. Focus is on the thermal control of instrumentation, sensors, and other heat dissipating equipment. Moderate to low temperature and long life applications will be stressed. This work will be accomplished through research into basic thermo-fluid phenomena under micro and partial gravity, development and test of various two-phase components and test verification, and small flight experiments.

W92-70059 **(55) 506-41**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
SPACE ENERGY CONVERSION RESEARCH AND TECHNOLOGY
C. P. Bankston 818-354-6793

The objective is to develop and demonstrate advanced technologies in the area of power switching and control; chemical energy conversion; photovoltaic energy conversion; and thermal energy conversion for spacecraft power systems up to 40kW. The principal goal is to develop power technologies that minimize power system mass, volume and parts count. Also, we seek to meet the power requirements of future missions that may include rovers, penetrators, and high temperature/pressure operation. Specific goals are progress in power switching and control functions from discrete to monolithic technologies leading to increases in power density from 1W/cu in. to more than 10W/cu in. and an 80 percent reduction in parts count; development and demonstration of photovoltaic array technology that produces nearly 300 W/kg and 300 W/m2 for earth orbital, planetary (to 5 A.U.), and electric propulsion missions; high cycle life, 100 W-hr/kg rechargeable batteries; and thermal-to-electric conversion technologies capable of efficiencies of at least 10 percent (thermoelectrics) or 20 percent (AMTEC). The approach includes industry tasks for prototype demonstration elements and university tasks.

W92-70060 **(62) 506-41**
Marshall Space Flight Center, Huntsville, AL.
SPACE ENERGY CONVERSION RESEARCH AND TECHNOLOGY
J. B. Haussler 205-544-1762

This effort is directed toward the evaluation of Long Duration Exposure Facility (LDEF) Experiment A0171, Solar Array Materials LDEF Experiment (SAMLE). A0171 contains approximately 100 materials/material processes, including solar cells with various welding materials and processes, composite materials, thin polymer films, metals, paints, solar reflectors and elastomeric materials.

Propulsion Research and Technology

W92-70061 **(22) 506-42**
Lewis Research Center, Cleveland, OH.
PROPULSION RESEARCH AND TECHNOLOGY
L. A. Diehl 216-433-2438
(590-21-00; 593-12-00)

The objective is to provide propulsion technology for future Earth-to-Orbit, Earth orbiting platforms and spacecraft, orbital transfer vehicles, space transfer vehicles, planetary spacecraft and lunar planetary descent ascent vehicles. Advanced propulsion will provide the capability to perform a variety of challenging space missions through major improvements in performance, reliability, operational flexibility and economy. Advanced high performance, reusable Earth-to-Orbit propulsion systems will extend component service life. High energy density propulsion systems will greatly reduce the size, mass, and cost of Earth-to-Orbit orbital vehicles, orbital transfer vehicles and lunar/planetary landers. Dependable, long-life, low-thrust primary and auxiliary propulsion systems, both chemical and electric, will provide the high performance and reliability needed for the extended in-space operation of Earth-Orbiting platforms and satellites and for planetary transfer vehicles and spacecraft. Cryogenic Fluid Systems will provide the capability to store, supply and transfer subcerifical liquids in the low gravity environment of space in an efficient and safe manner.

W92-70062 **(55) 506-42**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
PROPULSION RESEARCH AND TECHNOLOGY
P. W. Garrison 818-354-3575
(593-72-00)

The objective of this RTOP is to enable ambitious missions of space exploration in the 21st century. Research will be conducted to establish the feasibility of propulsion concepts which offer substantial performance increases relative to state-of-the-art propulsion systems. Critical technology development requirements will be addressed for the most promising near-term electric propulsion concepts -- noble gas ion engines and magneto-plasmadynamic (MPD) thrusters. The major outstanding technical issues impeding the application of ion propulsion include demonstration of engine life, engine throttling, and engine reliability. The approach to resolving these issues will include extended-duration component testing, the development of a novel segmented thruster design, and the use of the negatively-biased 3-grid technique for ion engine life testing. A new, dedicated ion engine life-test facility, capable of life-testing 10kW class ion engines, will be completed. MPD thruster research will include the development, application and experimental verification of electrode thermal models designed to address the critical issue of scaling

thruster input powers into the megawatt range. Investigation into the design and testing of lithium MPD thrusters will also be pursued. Other technologies to be investigated include advanced forms of fission rockets, fusion rockets, hybrid nuclear concepts, and advanced electric propulsion including microwave electrothermal rockets, electrodeless electromagnetic plasma accelerators, and electrostatic molecular ion accelerators. Systems studies will be conducted to determine the theoretical mission benefits of new concepts and to define the feasibility issues and proof-of-concept research required to ready promising technologies for mission application. Concepts found to merit further consideration will be investigated through proof-of-concept research to include theoretical and experimental studies at JPL and through contracts to universities, government laboratories, consultants, or private organizations.

W92-70063 **(62) 506-42**
Marshall Space Flight Center, Huntsville, AL.
PROPULSION RESEARCH AND TECHNOLOGY
M. S. Swint *205-544-4060*

Cryogenic Fluid Systems offers the potential to enable the storage and transfer of cryogenic fluids in low-Earth orbit. In-orbit resupply of spacecraft and space vehicles will result in a great reduction in required fluid margins by allowing for replenishment of propellants in Low-Earth Orbit. The objective of the Cryogenic Fluid Systems program is to develop the technologies required to store, supply, and transfer subcritical cryogenic liquids in the low-gravity environment of space in an efficient, safe, and reliable manner. The long-term goal of this technology program is to enable on-orbit storage and resupply operations for future spacecraft and space transportation vehicles required for the Space Exploration Initiation (SEI) and for low-Earth to geostationary-Earth orbit missions. The approach is to develop and validate the appropriate fluid and thermodynamic analytical models of the various fluid processes related to the management of subcritical cryogenic fluids in low gravity vacuum environments. These models will be validated to the maximum extent possible by conducting ground-based testing. For those fluid dynamic and heat transfer processes that are gravity dependent, space-flight experiments will be used to complete the validation of the models. The validated models will then be available for use in the design of future space vehicles and systems.

Materials and Structures Research and Technology

W92-70064 **(21) 506-43**
Ames Research Center, Moffett Field, CA.
MATERIALS AND STRUCTURES RESEARCH AND TECHNOLOGY
J. O. Arnold 415-604-5265
(506-40-00; 505-63-00)

The objective is to provide advanced materials technology for the development of future space systems with significant improvements in performance, durability and economy. Emphasis is given to computational materials science, hydrogen compatibility of advanced structural materials, and thermal protection materials development. In computational chemistry, the physical and chemical properties of molecules, small atomic clusters and gas-surface interactions are calculated from first principles. These and extrapolations to larger systems are being compared with experiment and to obtain surface and bulk properties. These results are used to study chemisorption, catalysis, corrosion and the physical properties of polymers. Ames' unique arc-plasma test facilities, ceramic and metallic materials laboratory, and analytical and computational capabilities are used to develop materials and optimized systems for advanced space transportation vehicles, enhanced Space Shuttle vehicles, aeroassisted space transfer vehicles (ASTV), transatmospheric vehicles (TAV), planetary and solar probes, and safe Earth reentry of radioactive power sources. Candidate thermal protection system (TPS) concepts and materials are subjected to systematic analysis and testing to qualify for defined end use. Improvements in arc-plasma technology will assure that NASA materials testing continues to be accomplished in state-of-the-art test facilities.

W92-70065 **(22) 506-43**
Lewis Research Center, Cleveland, OH.
MATERIALS AND STRUCTURES RESEARCH AND TECHNOLOGY
S. J. Grisaffe 216-433-3193

The objectives of this RTOP are to develop greater understanding of materials with aerospace propulsion and power potential and to develop guidelines for improving their physical/mechanical properties and reliability. Fundamental studies are aimed at investigating mechanical and other factors that limit material reliability, performance, and useful life. Fundamental studies are also aimed at identifying scientific concepts that might be applied to substantially improved aerospace materials. The research includes material properties/performance enhancement via innovative application of nondestructive evaluation concepts/models for characterization of microstructure and mechanical properties; understanding the basics of friction, wear, adhesion, thin film liquid lubrication, and the chemistry and morphology of solid lubricants; work to explore new ceramic matrix composites for aerospace applications; exploration of new materials for heat storage and space power applications; and fundamental chemistry of conductive polymer composites. The analytical and experimental results of this RTOP will have far reaching practical applications for a wide range of aerospace materials, structures, and components.

W92-70066 **(23) 506-43**
Langley Research Center, Hampton, VA.
MATERIALS AND STRUCTURES RESEARCH AND TECHNOLOGY
C. P. Blankenship 804-864-6005

The research includes executing analytical and experimental programs in structures and materials with emphasis on thermal structures and aerothermal effects; structural concepts; polymeric materials, metallic materials, and composite materials; and interdisciplinary analysis and optimization. The objective is to develop structures and materials technologies that will enhance the performance, efficiency, and reliability of spacecraft and space transportation systems. Analytical, computational, and experimental approaches are included in the fundamental research that is conducted in-house, by university grant, and under contract to industry.

W92-70067 **(55) 506-43**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
MATERIALS AND STRUCTURES RESEARCH AND TECHNOLOGY
Jovan Moacanin 818-354-3178

The objective is to develop and demonstrate advanced technology in the area of materials for dimensionally stable large structures and science instruments, and advanced methodologies for the design of large structural systems. An additional objective is to pioneer the development of technologies for autonomous acquisition and in-situ analysis of planetary minerals. Analytical and experimental research will be conducted to develop smart actuator materials for active vibration control of structures and for adaptive optics; emphasis will be on low operating temperatures (approximately 100 K), low operating power and large throw in order to make possible use of actuators for space applications. New design concepts, analysis capabilities, and verification techniques will have to be developed to implement development of large precision structures. The design process will require methodology development for on-orbit response predictions and

identification and the ability of the structure to adjust to its own static or dynamic characteristics.

W92-70068 **(62) 506-43**
Marshall Space Flight Center, Huntsville, AL.
MATERIALS AND STRUCTURES RESEARCH AND TECHNOLOGY
J. B. Haussler 205-544-1762

This effort consists of two tasks. The first task is directed toward the evaluation of Long Duration Exposure Facility (LDEF) Experiments A0034, Atomic Oxygen Stimulated Outgassing, A0172, Effects of Solar Radiation on Glasses, and S0069, Thermal Control Surfaces Experiment. These experiments all provide samples of materials that have been exposed to the environment of space for an extended period of time. Complex analyses are required to determine and understand the effects of this exposure. The second task has the objective to validate candidate welding approaches for potential use as in-space construction, fabrication and repair methods.

W92-70069 **(72) 506-43**
Lyndon B. Johnson Space Center, Houston, TX.
MATERIALS AND STRUCTURES RESEARCH AND TECHNOLOGY
S. L. Koontz 713-483-5906

Task 1 of this RTOP will provide funds to support continuing laboratory studies of space durable materials. The data base produced by these studies will support design and development of Space Station, other long lived LEO platforms, and the Moon-Mars initiative. Material and protective coating concepts providing long life in the LEO, Lunar and Martian environments will be identified. Factors limiting the life of important material classes will also be identified. The data base produced by these studies will lead to high confidence design of long-lived, low-maintenance spacecraft and space facilities. Task 2 of this RTOP will also provide funds to examine the effects of hypervelocity impact on non-metallic materials, investigate new shielding concepts, and begin investigation of debris sweeper concepts. The examination of the hypervelocity impact resistance of non-metallic materials and new shielding concepts will be conducted in the Johnson Space Center (JSC) Hypervelocity Impact Research Laboratory. Damage produced by debris plumes formed during hypervelocity impacts on thin sheets of non-metallic materials will be emphasized in this study.

Space Flight Research and Technology

W92-70070 **(21) 506-48**
Ames Research Center, Moffett Field, CA.
SPACE FLIGHT RESEARCH AND TECHNOLOGY
T. Gross 415-604-4951
(506-40-00; 506-43-00; 589-01-00)

The objective is to promote the utilization of the Space Transportation System Shuttle as a flight research platform and facility for technology research. The Shuttle will be used to obtain data on the operation of specific technologies in the space environment. The data is required to support and augment the research and technology base for advanced space flight systems. Through use of the facility, a better understanding of the function and operation of technologies for use in space, including those for fluid control and for fluids separation will be obtained. An experiment selected under the In-Space Technologies Experiment Program (INSTEP), designed to evaluate the characteristics and operation of membranes for fluid control, fluid separation and solutes separation will be studied. In addition, other technology experiments, proposed by universities, industry and NASA centers will be evaluated, and preliminary studies of proposed experiments will be supported.

W92-70071 **(22) 506-48**
Lewis Research Center, Cleveland, OH.
SPACE FLIGHT RESEARCH AND TECHNOLOGY
O. D. Gonzalez-Sanabria 216-433-5252
(589-01-00)

The objective of the Space Flight research and technology program is to provide experiment support for the definition and conceptual design of in-space technology experiments to bring the research and technology base forward to flight and provide the aerospace community with increased access to the national space facilities. The program elements contained in this submittal include the Industry/University Experimental Studies, and In-Space Research. The Experimental Studies provide definition and conceptual design studies of proposed in-space technology experiments which enable or enhance future exploration missions, improve space station capabilities, increase science spacecraft efficiency and validate essential system components for advance transportation systems. The In-Space Research provides experiment support, test facilities, accommodation assessment, and development of unique spacecraft hardware required to conduct in-space technology experimentation that will enable verification and validation of the technologies using the nation's space facilities.

W92-70072 **(23) 506-48**
Langley Research Center, Hampton, VA.
SPACE FLIGHT RESEARCH AND TECHNOLOGY
W. Ray Hook 804-864-6055
(506-40-00)

The objective of this research is the development of advanced space systems technologies through a broad-based program of in-flight experimental research. This program provides for data measurement and systems evaluation and verification in the true space flight environment, when such research cannot be adequately accomplished in ground-based simulations or facilities. The approach is to develop and fly instruments which make use of the Space Shuttle Orbiter as a research vehicle to obtain data to be used to improve our ability to extrapolate ground-based data and predictions to the actual entry environment for advanced space transportation systems; develop and fly instruments which use the orbiter as an in-orbit test platform on which to conduct experiments to improve our understanding of the orbital environment, and the atmospheric environment; develop requirements and instrumentation concepts that could be used in extracting in-flight data from any space test platform; and measure space environmental data from the Long duration exposure Facility (LDEF) structure and update the LDEF data bases with the information compiled by the Special Investigation Groups (SIG's).

W92-70073 **(51) 506-48**
Goddard Space Flight Center, Greenbelt, MD.
SPACE FLIGHT RESEARCH AND TECHNOLOGY
R. McIntosh 301-286-3478
(506-41-00; 506-43-00; 589-01-00)

The objective of this RTOP is to advance and enhance the research and technology base in those areas which require testing and demonstration in the space environment. The program currently encompasses the Phase B design of two thermal management and fluid physics experiments. The first is designed to study the sloshing behavior of fluids in rotating tanks in the shuttle mid deck. The second will fly on a Hitchhiker carrier and will evaluate a novel high performance two phase heat exchanger which can only be tested properly in microgravity. The second aspect of this program involves the integration of flight experiments on the Hitchhiker and SPARTAN carriers. The objective of this effort is to provide support to the experiments planned for the OAET-1 and OAET Flyer missions. In addition, necessary unique carrier hardware required for these missions will also be developed.

W92-70074 **(55) 506-48**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
SPACE FLIGHT RESEARCH AND TECHNOLOGY
A. B. Chmielewski 818-354-0255
(589-01-00)

The Jet Propulsion Laboratory (JPL) will provide support to NASA Headquarters (HQ) for the In-Space Technology Experiments Program (IN-STEP). This support encompasses procurement and management of two phase B industry experiments: the Inflatable Antenna and Cryogenic System Experiment. As a part of managing the experiments JPL will assemble experts to consult on technical merits of the experiments in such areas as thermal, vibration, integration, systems, structures and the specific technology areas of the experiments: communications and cryogenics. JPL will provide Quality Assurance monitoring for both experiments. Second, JPL will provide technical and programmatic support to IN-STEP, including: Non-Advocate Reviews of other IN-STEP experiments, Announcement of Opportunity (AO) 91 process, assistance to proposers to the new AO, quarterly reports, RTOP process, RTOP reviews by Code RX at JPL, workshops, technology themes definition, and IN-STEP interfaces with other Code R Divisions, NASA Codes, industry and universities. JPL will also participate in the reviews of the Maser Experiment managed by Langley Research Center. Finally, JPL will provide a detailee to NASA HQ to assist with program management, especially in conjunction with the new AO. JPL will also develop institutional expertise in space flight carriers for small experiments. After conducting trade studies, the best flight carrier will be selected for both the Inflatable Antenna and Cryogenic System Experiment.

W92-70075 **(62) 506-48**
Marshall Space Flight Center, Huntsville, AL.
SPACE FLIGHT RESEARCH AND TECHNOLOGY
J. B. Haussler 205-544-1762

This effort supports the Long Duration Exposure Facility (LDEF) Ionizing Radiation Special Investigation Group (IRSIG), the In-Space Technology Experiment Program (IN-STEP), and provides for the Phase B efforts for two IN-STEP flight experiments; the Hydrogen Maser Clock and the Optical Properties Monitor (OPM). The principal objective of the IRSIG is to use LDEF data to rigorously test the accuracy of present models and methods for predicting ambient environment particle fluences and spectra, dose linear energy transfer spectra, secondary particles such as neutrons and recoils, and some radiation effects. The IRSIG program will also test a new model of trapped protons that includes directional effects. This analysis program will include recommended modifications to models and methods for improved accuracy. The primary objective of the Hydrogen Maser Clock flight experiment is to understand the performance characteristics of a new very high stability hydrogen maser clock system intended for long term continuous operation in space. The Optical Properties Monitor provides a comprehensive space research capability for studying the effects of the space environment (both natural and induced) on optical, thermal, space power, and other materials.

W92-70076 **(72) 506-48**
Lyndon B. Johnson Space Center, Houston, TX.
SPACE FLIGHT RESEARCH AND TECHNOLOGY
R. L. Giesecke 713-283-5340

The objective of the Orbiter Experiments (OEX) program is to collect data in the technology disciplines that will augment the research and technology base for future spacecraft design. Flight data relative to these disciplines will be collected by the development of unique experiments compatible with the flight operational capabilities of the Orbiter. This RTOP includes the effort associated with overall project management, project support, experiment development initiation, experiment compatibility assessments, experiment integration activities, and integration hardware development. For the in-space experiments programs, technical support will be provided for the assessment of selected proposals prior to initiation of Phase A concept development, Phase B engineering studies, and Phase C/D hardware development and flight and to make recommendations concerning complementary/compatible experiment groupings and possible experiment flight opportunities. The objectives of the Long Duration exposure Facility (LDEF) Impact Record task are to qualify the understanding of the hypervelocity particle environment in Low Earth Orbit (LEO) and to better define the collisional hazards to manned and unmanned spacecraft.

Systems Analysis

W92-70077 **(21) 506-49**
Ames Research Center, Moffett Field, CA.
SYSTEMS ANALYSIS
R. R. Meyer 805-258-3707
(505-59-00)

The objective of this effort is to conduct basic aerodynamic and aerothermal flight research in order to allow timely and reliable design of advanced hypersonic transportation systems. Critical gaps exist in the current data base which may not be filled with conventional test and analysis. Some of these gaps can be closed through experiments which can be conducted on existing and proven flight vehicles at reasonable cost. Results will allow calibration and validation of the tools needed to design mission-oriented vehicles. Related test technique development must be addressed concurrently. Another objective of this RTOP is to conduct research on advanced remote sensing technology leading to the development of airborne and spacecraft imaging instrumentation optimized for the measurement of the biochemical composition of the plant canopies of Earth's biosphere. The approach taken has been based on the research and development recommendations of a scientific workshop held in July of 1990. Laboratory investigations and contracted studies of spectroscopic sensing elements (detector arrays, spectral filters, optics, lasers, and so on) will be conducted to determine performance, permitting new sensing techniques such as imaging derivative spectroscopy. These investigations will be done in conjunction with greenhouse experiments on selected plants.

W92-70078 **(22) 506-49**
Lewis Research Center, Cleveland, OH.
SYSTEMS ANALYSIS
H. W. Brandhorst 216-433-6149

The objective of the Systems Analysis RTOP is to identify technical requirements for advanced space systems which satisfy national needs and to synthesize these requirements into comprehensive and timely technical development plans; to develop research and technology programs which satisfy these requirements; and to support conceptual design and development of future space systems via systems level analysis and supporting flight research. The approach includes in-house and contracted system analysis which will be performed for three separately-managed elements: transportation systems, space science systems, and a Space Platforms system.

W92-70079 **(23) 506-49**
Langley Research Center, Hampton, VA.
SYSTEMS ANALYSIS
W. Ray Hook 804-864-6055

The technical objectives of this research are to identify technology requirements for advanced space systems and to synthesize these requirements into comprehensive and timely technology development plans; to advocate research and technology development programs which satisfy these requirements; and to support conceptual design and development of future spacecraft, advanced Earth- and space-based transportation vehicles, lunar and planetary transportation systems and large space antennas, platforms, and space stations via

system-level analyses and supporting flight research. In-house and contracted analytical capabilities and computational and experimental facilities will be utilized to accomplish these objectives. Computer-aided engineering, design, and simulation capabilities will be expanded to meet the analysis and technology assessment needs.

W92-70080 **(51) 506-49**
Goddard Space Flight Center, Greenbelt, MD.
SYSTEMS ANALYSIS
Henry H. Plotkin 301-286-6185

Potential future space science missions and operations systems are studied in order to identify technology barriers, highlight breakthrough technologies, and assess benefits including such new technologies in mission planning. Emphasis this year is on X-ray Optics Technology and sensor optical systems requirements to be derived from Astrophysics Observatory mission and Space Exploration Initiative concepts, and on information systems requirements for Mission to Planet Earth. Requirements to advance capabilities of science data archive and retrieval systems needed by remote sensing and super computing facilities in the next decade will be studied. An archive concept and software architecture must be formulated which incorporates labeling, acquisition strategies, object oriented and spatial data management, etc. The next generation of x-ray instruments will be drivers for new x-ray mirror fabrication technology. Techniques such as ion polishing, plasma assisted chemical etching, and actively controlled lapping will be evaluated. We will also consider technology areas such as modelling/analysis, metrology, gratings, filters, binary optics, and calibration for long term stability.

W92-70081 **(55) 506-49**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
SYSTEMS ANALYSIS
Frank Surber 818-354-2338

The objectives are to identify critical technology needs for future high priority NASA missions and to assist in the formulation of the necessary supporting technology development programs. Studies will continue to contribute to technology planning for the astrophysics, solar system exploration, earth sciences, life sciences, and space physics missions. Integrated information systems analysis will also continue, leading to better understanding of multimission information systems requirements and critical technology needs. A new effort to define the technology needs for mission operations and the system analysis, design, and engineering process may be initiated. To ensure the achievement of greatest scientific return and maximum cost effectiveness, technological approaches will be carefully evaluated in terms of capability, performance, risk, and cost. Resulting information on the benefits, costs, and development plans/schedules for each of the technologies considered will be presented to NASA program managers.

W92-70082 **(62) 506-49**
Marshall Space Flight Center, Huntsville, AL.
SYSTEMS ANALYSIS
J. B. Haussler 205-544-1762

This effort will perform studies relating to the requirements associated with the next generation of space and lunar based optical systems. Three primary studies will be developed: one involving controls/structures/thermal interactions on optical performance, and the other involving determination of associated optical metrology requirements; and one involving optical technology applied to the Global Change initiative.

W92-70083 **(62) 506-49**
Marshall Space Flight Center, Huntsville, AL.
SYSTEMS ANALYSIS
E. Montgomery 205-544-1767

The objective of this technology program is to perform research and technology work leading to development of a ground-to-space beamed power system. Potential applications include power for orbiting elements in Low Earth Orbit (LEO) or Geosynchronous Earth Orbit (GEO), for space vehicles, and for lunar surface elements. On-going and previous work done by NASA, DoE, and DoD, will be utilized to the extent feasible. Development and demonstration of a prototype operating system concepts is planned. At present, the principal concept of interest utilizes a ground-based laser system and beam expander having an active optics capability to correct for atmospheric disturbances of the beam. A photovoltaic array in space would be used to receive this beam and convert it to electrical energy at the location desired. In such an approach, the optics technology would be supportive of other applications (ground-based and space-based) as well as beamed power applications. One potential prototype demonstration concept would transmit power from the ground to existing Apollo reflectors on the lunar surface, with the returned signal being analyzed for transmission quality. Such a system might initially have only partial power and optics capability, but would be upgradable to a full-capability system.

W92-70084 **(72) 506-49**
Lyndon B. Johnson Space Center, Houston, TX.
SYSTEMS ANALYSIS
R. B. Ramsell 713-282-5377

The objective of this RTOP is to investigate technology options for Space Station Freedom (SSF) design and evolution and for the use of SSF as a technology development test bed. The FY-92 activities consist of three tasks. The first task, interaction with multi-tasking, investigates the human-computer interface requirements needed in the increasingly complex multi-task environment envisioned. The second task, microgravity effects on advanced environmental control and life support systems (ECLSS), develops designs for an advanced ECLSS test bed for investigation of long-term microgravity effects. The third task, manned observation technologies, evaluates the information content of imagery recorded in flight tests on different types of media.

University Space Research

W92-70085 **(55) 506-50**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
UNIVERSITY SPACE RESEARCH
K. Aaron 818-354-2816

The objectives of this RTOP are to: (1) apply JPL skills in support of space systems engineering design courses at selected universities; and (2) support summer residencies at JPL of selected students from those universities. A designated JPL mentor works with university faculty and students during the academic year providing or arranging for JPL support in the form of lecturers from JPL, information from JPL and NASA sources, consulting, and attendance at preliminary and critical design reviews. The JPL mentor is also expected to attend annual NASA/Universities Space Research Association (USRA) meetings and to consult as appropriate with USRA, other Center mentors, and faculty at other universities in the program.

Information and Controls Research and Technology

W92-70086 **(21) 506-59**
Ames Research Center, Moffett Field, CA.
INFORMATION SCIENCES RESEARCH AND TECHNOLOGY
C. R. McCreight 415-604-6549
(590-31-00; 505-64-00)

One objective is to develop advanced infrared detector array

technology for future astronomical applications. The array technology is applicable to low- and moderate-background applications throughout the infrared spectrum and will directly benefit programs such as the Space Infrared Telescope Facility (SIRTF) and the Large Deployable Reflector (LDR). These activities include extensive in-house characterization. The second objective is to develop real-time optical processors for airborne and spaceborne applications. This research is centered around development of compact optical systems for real-time autonomous vision and high bandwidth matrix operations applied to data analysis and the control of large structures. The approach involves extensive in-house technology demonstrations coordinated with user requirements for applications in autonomous construction, exploration, and control. A third objective is to develop effective methods for screening, analyzing, and processing the unprecedentedly large, high-dimensional data sets that will be produced by future NASA missions. A promising new method of this kind is Gaussian Windows, an interactive tool for data exploration. Work on Gaussian Windows will be carried out by Ames' Research Institute for Advanced Computer Science (RIACS).

W92-70087 **(55) 506-59**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
INFORMATION AND CONTROLS RESEARCH AND TECHNOLOGY
Richard W. Key 818-354-3060

The objective is to develop advanced technologies in the areas of computer science, data systems, photonics, sensors and control. Computer science research will demonstrate an easy to use and inexpensive cataloging technique to facilitate software reuse. Advanced Data Concepts work will develop neural network based erasable, programmable, non-volatile synaptic memories to demonstrate their unique potential for solving complex information processing problems. Photonics work will involve development of optoelectronic integrated circuits for optical communications, computing, and instrumentation and investigation of space environmental effects on fiber optics. The sensor research will develop semiconductor lasers and laser arrays for injection seeding and pumping of newly developed solid-state lasers and will focus on high temperature superconducting thin film research. Controls research will produce new computational design tools that will reduce the time and cost required to develop spacecraft control systems. Advanced metrology concepts with nanometer level performance will be developed for large optical space interferometers. Development of the Fiber Optic Rotation Sensor (FORS) will produce a single axis engineering model.

W92-70088 **(62) 506-59**
Marshall Space Flight Center, Huntsville, AL.
INFORMATION AND CONTROLS RESEARCH AND TECHNOLOGY
J. F. MacPherson 205-544-5936
(590-14-00)

The overall objective of this research is to define, develop, and demonstrate advanced control concepts for the stabilization and control of future spacecraft, payload pointing systems, and advanced transportation vehicles. The work is focused on three primary areas: the stabilization and control of large flexible structures in space and advanced control techniques for the next generation of space transportation vehicles. In the first areas, the effort will be a continuation of the ongoing analytical and experimental investigation of flexible body control techniques. Here, the principal end product will be new control techniques for pointing, slewing, and actively rigidizing large systems in space. The second area represents an expansion in scope to address improvements in vehicle control design practice which will result in reduced transportation systems operational cost and at the same time enhance system reliability and utility. In the third area, computational methodologies will be explored, developed, and investigated to enhance dynamic and control procedures for large order systems.

W92-70089 **(72) 506-59**
Lyndon B. Johnson Space Center, Houston, TX.
INFORMATION AND CONTROLS RESEARCH AND TECHNOLOGY
J. W. Sunkel 713-483-8591

The objective is to develop and assess guidance, navigation, control and software engineering concepts, techniques, and design methodologies to provide needed capabilities for full and cost-effective utilization of current and future space systems. Methodologies for cost-effective development, implementation, and verification of control capabilities will also be evaluated. Technology needs will be addressed across interacting space elements, including the Space Shuttle, the Space Transfer Vehicle (STV), Manned Maneuvering Units (MMU's), free-flyers, aeromaneuvering planetary and earth return vehicles, and the Space Station. Emphasis will be placed on the development of control technologies supporting integrated orbital operations and services. Software engineering areas of research include: new models, methodologies, and paradigms to advance the life-cycle engineering of software; productivity tools for software development and maintenance; development and maintenance of distributed information systems; software fault tolerance and systems survivability; use of the Ada language and associated environments on NASA projects; and application of expert systems and artificial intelligence techniques to life-cycle software management. The approach used will be to conduct studies, analyses, and trade-off studies to define hardware and software requirements.

W92-70090 **(23) 506-59**
Langley Research Center, Hampton, VA.
INFORMATION AND CONTROL RESEARCH AND TECHNOLOGY
J. F. Creedon 804-864-6033
(590-14-00)

This RTOP provides: (1) fundamental and applied guidance, navigation, and control (GN&C) research and technology for advanced spacecraft, space transportation systems, and large, flexible space structures/platforms; (2) development of technology for advanced information processing systems for space applications; (3) development of microwave remote sensor technology for geostationary and low Earth orbit applications; (4) development of electromagnetic (EM) analysis methods for predicting the performance of large aperture systems; and (5) evaluation of the effect of long space exposure on active optical system components. The approach includes: (1) developing basic control theories; (2) applying advanced modeling techniques and on-line identification in conjunction with dynamic models of large flexible space systems, advanced transportation system concepts, and reentry vehicles; (3) evaluating resulting GN&C system in simulations and ground and flight test programs; (4) extending electromagnetic analysis methods already in existence to predict performance of large aperture microwave radiometers; (5) developing concepts for large deployable antennae; and (6) testing concepts on laboratory testbeds.

W92-70091 **(51) 506-59**
Goddard Space Flight Center, Greenbelt, MD.
INFORMATION AND CONTROLS RESEARCH AND TECHNOLOGY
Henry H. Plotkin 301-286-6185
(506-72-31)

This RTOP includes researching computer sciences, space science sensor systems, applications of high temperature superconducting materials, and dynamic controls analysis. Environments are developed for software management and knowledge-based software engineering. Automated approaches are developed for encoding and analyzing multispectral imaging data. Artificial Intelligence (AI) approaches are used to access and

manage large, diverse, and complex data and knowledge bases. Concurrent processing algorithms are developed for computers having many parallel high speed processors. Support to the University/Government Center for Space Data and Information Systems (CESDIS) is continued. Advanced detectors are being developed which greatly improve spectral and spatial resolution for future X-Ray, Gamma-Ray, and Cosmic Ray astrophysical and planetary observations. Thin film and bulk material devices are being developed using recent results from high temperature superconductivity research. Current developments include broad-band infrared bolometer detectors, sensitive Superconducting Quantum Interference Device (SQUID) magnetometers, vibration damping mechanisms, and passive magnetic levitated bearings.

Human Support Research and Technology

W92-70092 **(21) 506-71**
Ames Research Center, Moffett Field, CA.
HUMAN SUPPORT RESEARCH AND TECHNOLOGY
R. K. Dismukes 415-604-5729
(505-64-00; 199-06-12)

The overall objective of this RTOP is to develop a research and technology base in life support systems, Extravehicular Activity (EVA) technology, and crew station design. The objective of the Advanced Life Support activities is to develop new and improved physical/chemical process technologies for air revitalization, water reclamation, and solid waste management that will provide the basis for integrated, closed-loop life support systems and further the development of portable life support systems necessary for EVA. The approach is based on test stand and testbed experimental studies supported by state of the art process modeling. New concepts and ideas for life support process technologies will also be investigated as well as the development of sensor and instrument technologies. Crew station design technology has as its goal the development of a technology base for advanced crew stations, operator interfaces, crew support systems for information management, and crew interfaces for the monitoring, and control of autonomous subsystems. Research will be conducted in laboratories, simulators, testbeds, and operational settings at various NASA Centers. Demonstration of interfaces and crewstation technology will be conducted in engineering testbeds at ARC and in operational settings at JSC and other NASA Centers.

W92-70093 **(72) 506-71**
Lyndon B. Johnson Space Center, Houston, TX.
HUMAN SUPPORT RESEARCH AND TECHNOLOGY
Barbara J. Woolford 713-483-3701

The objectives of this RTOP are to increase the safety and productivity of human performance in space, and to aid designers in planning spacecraft systems and operations that enhance safety and productivity. The approach to this is three-fold. The interfaces between humans and computers is a major area of research because so many spacecraft systems are computer controlled. The software may be procedural or intelligent, requiring different considerations in operating it. Basic research is performed in these areas, and tools developed to help in the design of interfaces to computers. Standards and guidelines based on human factors considerations and past experience in space are another necessity for design of good spacecraft and operations design. This RTOP supports the Man-Systems Integration Standards, NASA-STD-3000, and the operational data base which summarizes past flight experience and presents lessons learned. These two resources are available to designer for use in considering new equipment and operations. Extravehicular Activity (EVA) operations are made more efficient and safer through better equipment and planning tools.

Space Communications Research and Technology

W92-70094 **(22) 506-72**
Lewis Research Center, Cleveland, OH.
SPACE COMMUNICATIONS RESEARCH AND TECHNOLOGY
J. W. Bagwell 216-433-3502
(643-10-01; 643-10-05; 646-10-00)

The overall objective of this RTOP is to provide through research, development, and experimental tests, the devices, components, and subsystems comprising a suite of enabling technologies for new and improved space communications systems in support of NASA missions and the U.S. commercial communication satellite industry and other government agencies. To achieve this objective, advanced research and development programs will be conducted in the following areas: electron beam devices and components; solid state devices and components; antenna systems incorporating active and passive phased arrays; digital components and subsystems; radio frequency (RF) components and subsystems, and systems validation and testing. Work is performed in-house, on contract, and at universities for the purpose of developing advanced communication technology to enable systems that are frequency spectrum and power efficient to have longer life and to be low in weight and volume. Technology development is primarily focused on frequencies of 20 GHz to 94 GHz at information rates up to 1 GBPS.

W92-70095 **(23) 506-72**
Langley Research Center, Hampton, VA.
SPACE COMMUNICATIONS RESEARCH AND TECHNOLOGY
J. F. Creedon 804-864-6033

The objective is to develop and demonstrate high power, high modulation rate and single spectral and spatial emission semiconductor diode lasers for optical communication applications. Space qualified lasers and components with long-term stability and lifetime will be demonstrated. The approach is to: grow semiconductor laser quantum well material by metal organic chemical vapor deposition; fabricate high power laser arrays; phase together the various array structures; and demonstrate their operational characteristics. High power arrays will be characterized, evaluated, and the design iterated in order to achieve higher power lasers. The current approach utilizes a monolithic active-grating master-oscillator power-amplifier laser design which is expandable in power by the addition of more power amplifier sections. Additional studies to space qualify components and lasers for use in space will be performed.

W92-70096 **(51) 506-72**
Goddard Space Flight Center, Greenbelt, MD.
SPACE COMMUNICATIONS RESEARCH AND TECHNOLOGY
M. Fitzmaurice 301-286-8006
(650-76-00; 506-59-41)

This RTOP will develop and demonstrate high data rate optical communication technology for future NASA missions in the near-Earth environment. Emphasis will be placed on fully functional systems which have been designed to typical spacecraft interfaces; the engineering characteristics of these systems (i.e., weight, power, volume) will be representative of what is permitted by the current state of the art technologies. The communication link is nominally a Geosynchronous Earth Orbit (GEO)-to-GEO crosslink such as that being considered for the Advanced Tracking and Data Relay Satellite System (ATDRSS). The communication system will be capable of full duplex operation at a rate of 50 MBPS.

The optical communication system will utilize AlGaAs semiconductor lasers, which will transmit digital data using a 4 slot pulse position modulation format. Direct detection methodologies will be employed at the receiver. Wideband receivers which use silicon avalanche photodiodes with hybrid integrated pre-amplifiers will detect the incoming intensity modulated signal. Bit synchronizers which have the necessary sensitivity, bandwidth, and low power dissipation will be developed at the LeRC and will be integrated into the system for end-to-end testing.

W92-70097 **(55) 506-72**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
SPACE COMMUNICATIONS RESEARCH AND TECHNOLOGY
A. L. Riley 818-354-0401
(643-10-00; 310-20-00)

The objectives of this RTOP are to develop critical, high risk technologies which have the potential to enhance commercial satellite communications systems and high data rate communications systems for NASA applications. Specific objectives are the development of high rate optical communications components and systems for deep space communications; advanced Ka-band mobile terminals to be operated from the Advanced Communication Technology Satellite (ACTS) communications satellite system; and advanced technology for mobile communications. The optical portion of the RTOP will concentrate on the development of a 2-Watt frequency-doubled Nd:YAG laser; demonstration of spatial tracking of an extended image tracking beacon (such as the solar-illuminated earth); development and demonstration of optical coherent detection and spatial tracking techniques; architectural design of a breadboard optical communications payload package; and the application of advanced materials to the development of flight qualifiable optical modules. Ka-band fixed and mobile communication terminals will be developed for experimentation with ACTS. This will involve the development of multirate speech codecs (2400 to 9600 bps), robust multirate modems for the communications channel, transceivers, and medium gain, steerable, low profile vehicular antennas. This equipment and the various system concepts and algorithms will be tested and demonstrated in a series of experiments with ACTS. In addition to the required equipment for the terminals, a data acquisition system for recording and analysis of real-time experimental data will be developed. The mobile communications technology element will focus on mobile communications antennas, codecs, and modems. The initial thrust of this work will be in the antenna area to develop Ka-band phased array antennas utilizing Monolithic Microwave Integrated Circuit (MMIC) devices.

In-Space Technology Experiments

In-Space Experiments

W92-70098 **(21) 589-01**
Ames Research Center, Moffett Field, CA.
IN-SPACE EXPERIMENTS
R. D. MacElroy 415-604-5573
(506-48-00)

The objective is to utilize the Space Shuttle as a flight research facility to obtain data to support and augment the research and technology base for advanced space transportation systems. A flight experiment will be developed to test semipermeable and permeable membrane performance in the microgravity environment. The results of the experiment will supply fundamental data about the microgravity behavior of membrane-fluid interface over extended time periods. The experiment objective is to verify that membranes are suitable for use in a variety of life support devices on Space Station Freedom and Spacelab.

W92-70099 **(22) 589-01**
Lewis Research Center, Cleveland, OH.
IN-SPACE EXPERIMENTS
O. D. Gonzalez-Sanabria 216-433-5252
(506-48-00)

The In-Space Technology Experiments Program supports definition and development of the in-space technology experiments to flight evaluate and validate advanced technologies for future space systems. This RTOP supports Phase C/D (flight development). There are two program elements in this submittal: NASA Space Technology Experiments and Industry/University Experiments. The NASA Space Technology Experiments address advanced space technologies being developed at LeRC. Some of the experiments may be developed and conducted in cooperation with international partners or other government agencies. The Industry/University (I/U) Experiments address the technologies conceived and developed under industry independent research and development. Lewis Research Center manages NASA and Industry/University flight projects in two technology themes: Power Systems, and Propulsion and Propellant Management. Included are two NASA flight projects: Solar Array Module Plasma Interaction Experiment (SAMPIE) and Thermal Energy Storage (TES); and three I/U flight projects: the Tank Pressure Control Experiment (TPCE), Boeing; Vented Tank Resupply (VTR), Martin Marietta; and Sodium-Sulfur Cell Technology (Na-SCT), Space Systems/Loral.

W92-70100 **(23) 589-01**
Langley Research Center, Hampton, VA.
IN-SPACE EXPERIMENTS
F. Allario 804-864-6027

The technical objectives are to analyze and report the results of the Mid-Deck 0-Gravity Dynamics Experiment (MODE), and to complete the design and initiate the development of the Mid-Deck Active Controls Experiment (MACE), the Jitter Suppression Experiment, and the Joint Damping Experiment. Contracted efforts will be conducted to complete the work on MODE, and to initiate the design and development of the Joint Damping, Jitter Suppression, and the MACE experiments.

W92-70101 **(51) 589-01**
Goddard Space Flight Center, Greenbelt, MD.
IN-SPACE EXPERIMENTS
R. McIntosh 301-286-3478
(506-48-00; 506-41-00; 506-43-00)

The objective is to develop NASA space technology and industry/university flight experiments, which require access to space, to investigate critical technology needs. The program currently includes experiments dealing with thermal management, fluid dynamics, contamination modeling and measurements, and degradation of x-ray optics due to the effects of atomic oxygen. The experiments will be flown on the NASA Space Shuttle and Spartan on Hitchhiker carriers and in the mid-deck lockers of the shuttle. The information gathered from these experiments will benefit a broad class of future NASA, DOD, and private sector missions.

W92-70102 **(55) 589-01**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
IN-SPACE EXPERIMENTS
A. B. Chmielewski 818-354-0255
(506-48-00)

JPL will provide support to NASA Headquarters in execution and management of hardware development for the Cryogenic System Experiment. A phase C/D contract will be procured with Hughes Aircraft Company. JPL will manage this contract and provide expertise in integration, safety, reliability and quality assurance.

W92-70103 **(62) 589-01**
Marshall Space Flight Center, Huntsville, AL.
IN-SPACE EXPERIMENTS
B. J. Schrick 205-544-1279
(506-48-00)

The objective is to develop, operate in orbit, and evaluate the data of payloads that will advance the technology in areas of high energy radiation (cosmic ray) measurement, materials stability in a space environment, and long term frequency stability of hydrogen masers in the orbital environment. These payloads will be designed, manufactured, tested, integrated on carriers, launched on the Space Transportation System (STS), operated in orbit and returned for data analysis. ECT will use the Hitchhiker for a carrier on a mid-1993 STS launch and OPM and HMC are planning for a flight on European Retrievable Carrier (EUREGA) which will remain in orbit approximately six months. ECT Experiment is a passive sensor that records cosmic radiation with specifically designed and arranged layers of emulsions contained in a sealed container. OPM will monitor various aspects of the changes in the optical properties of selected material samples with three different instruments and will monitor the space environment with three different sensors. The HMC will be developed in a configuration that is similar to previously built Smithsonian Astrophysical Observatory (SAO) Maser Clock with refinements to provide high long term stability and adaptation for orbital flight. Ground based laser ranging and hydrogen maser clocks will be used to establish all the required experimental parameters.

W92-70104 **(72) 589-01**
Lyndon B. Johnson Space Center, Houston, TX.
IN-SPACE EXPERIMENTS
K. E. Henderson 713-283-5307
(506-48-00)

The objective is to conduct technology experiments in space as a way to introduce advanced technology into flight programs and to demonstrate the feasibility of conducting experiments in space. The In-Space Experiments Program will provide access to space for industry, university, and government participants and therefore serve as a conduit for the aerospace community for technology development in space. Work being conducted in the In-Space Technology Experiments Program will be carried out through in-house research, contracts with aerospace firms, and university grants. NASA Space Technology Experiments is being submitted as an overguidelines task. This task will be a flight experiment of the Debris Collision Warning Sensor (DCWS). This is a Shuttle payload bay experiment consisting of a telescope equipped with visible and thermal infrared detectors to sample LEO debris environment for objects greater than or equal to 1 mm. diameter. Data will be used to design a collision warning system as well as to update models of the debris environment. Industry/University Experiments consists of two tasks for the development of Shuttle flight experiments: (1) an experiment to investigate glow emissions in the ultraviolet, visible and infrared wavelengths to improve the understanding of glow emissions from spacecraft; and (2) an experiment to determine if low gravity conditions of space improve the performance of water electrolysis and possibly other electrochemical processes.

Civil Space Technology Initiative Program

Operations

W92-70105 **(22) 590-13**
Lewis Research Center, Cleveland, OH.
HIGH-CAPACITY POWER
H. W. Brandhorst 216-433-6149

The NASA CSTI High Capacity Power Program is intended to augment the SP-100 Power System Qualification (PSQ) being conducted by DOE/SDIO/NASA and is structured to enhance the chances of success for the overall SP-100 nuclear power system development. The Program goals are focused on providing component and subsystems options for increased efficiency, growth at reduced weights, and longer lifetime with higher reliability. These goals will be attained by conducting the broad based research and technology program which includes the following elements: systems analysis to guide the research and technology efforts and to identify the pay-offs; conversion systems for nuclear applications; thermal management; power management; systems diagnostics; and environmental interactions.

W92-70106 **(55) 590-13**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
HIGH-CAPACITY POWER
C. P. Bankston 818-354-6793

The objective is to develop and demonstrate solid-state thermal to electric power conversion technology that meets the long lifetime (10 yr), high efficiency (10 percent or greater) requirements of future high capacity space power systems. The eventual goal is high power density systems that meet mission requirements and minimize system mass, particularly for SP-100 type systems. Specifically, high efficiency thermoelectric materials based on silicon-germanium type semiconductor materials will be developed. The major activities focus on optimizing dopant concentrations for n-type silicon-germanium materials to maximize Seebeck coefficient; and to reduce thermal conductivity of n-type silicon germanium by the addition of phonon scattering centers. Also, preliminary efforts to identify potential next generation thermoelectric materials for high capacity power generation will be initiated.

W92-70107 **(23) 590-14**
Langley Research Center, Hampton, VA.
CONTROLS-STRUCTURES INTERACTION (CSI)
J. F. Creedon 804-864-6033

The overall objective of the CSI (Control/Structure Interaction) Program is to develop and validate the technology needed to design, verify, and operate spacecraft in which the structure and the control interact beneficially to meet the requirements of 21st-century NASA missions. Long-term goals of the effort are as follows: (1) to provide spacecraft dynamic response amplitude reductions of 50 percent, for any input or maneuver, with minimum increase in system mass; (2) to enable the use of wide-bandwidth CSI control systems to achieve several orders of magnitude improvement in control and pointing capabilities; (3) to predict the on-orbit performance of CSI systems to within 10 percent of all amplitude, frequency, time, and stability requirements based on the results of integrated analyses tuned/corrected by closed-loop ground and/or flight test data; (4) to develop unified controls-structures modeling, analysis, and design methods which allow a complete iteration on all critical design variables in a single integrated computational framework; and (5) to develop the capability to validate the performance of flight systems by analysis/ground tests.

W92-70108 **(55) 590-14**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
CONTROLS/STRUCTURES INTERACTION
R. A. Laskin 818-354-5086

The long range objective is to identify, develop and validate the Control/Structure Interaction (CSI) technology for integrated control/structure spacecraft design that is necessary to achieve future mission goals. This research program is part of a comprehensive NASA-wide CSI research program which is concentrated in the areas of: new integrated control/structure concepts, integrated control/structure analysis and design methodology, ground testing, and on-orbit testing. A unified team of researchers from the structures and controls disciplines is participating in the development of a multi-discipline approach in these areas. Research performed at JPL is coordinated with the

other participating NASA centers and concentrates on the CSI technology area of micro-precision controlled structures. Focus missions will be used to demonstrate the advantages of applying CSI technology in terms of reduced development costs and improved operational performance. The design methods, models, and system concepts will be validated through ground testing. Flight tests will be proposed for those essential elements that require the on-orbit environment.

W92-70109 **(62) 590-14**
Marshall Space Flight Center, Huntsville, AL.
CONTROLS/STRUCTURES INTERACTIONS
J. F. MacPherson 205-544-5936
(506-59-00)

The objective is to develop a Ground Test Facility (GTF) to perform the advanced development studies for the Control and Structures Experiment in Space (CASES) program. The CASES flight experiment will demonstrate the flight readiness of several key Control Structure Interactions (CSI) methodologies in the early 1990's. Thus enabling future NASA science missions requiring CSI technology to be able to proceed on course. The approach toward CASES will be to develop a prototype GTF under this RTOP in support of the CASES definition, design, and development phases. To minimize technical and cost risks, the flight proven OAST-1 test structure will be utilized in CASES. The definition phase (Phase B) was completed in FY-90. The Phase-B results will be utilized in the CASES - GTF to develop an operational methodology for CSI related spacecrafts. In addition, the GTF will also support the CSI Guest Investigator Program.

Transportation

W92-70110 **(22) 590-21**
Lewis Research Center, Cleveland, OH.
EARTH TO ORBIT
L. A. Diehl 216-433-2438

The objective is to provide the knowledge, understanding, and design methodology that will enable the development of advanced high-performance, reusable Earth-to-orbit propulsion systems with high design margins for extended component service life, and with autonomous ground and flight operations. LOX/hydrocarbon propellant systems and components will receive attention in order to provide the technology base necessary to design and evaluate their impact on future Earth-to-orbit vehicle size, mass and cost. Although focused on reusable manned vehicles, the resulting technology advancements and design and development tools will be applicable to a wide range of future engine design options, including expendable or partially reusable cargo delivery vehicles as well as growth versions and derivatives of the Space Shuttle.

W92-70111 **(23) 590-21**
Langley Research Center, Hampton, VA.
EARTH TO ORBIT
W. Ray Hook 804-864-6055

The technical objective is to assess the impact of advanced rocket, airbreathing, combined cycle, and innovative propulsion technologies on future Earth-to-orbit transportation systems in terms of vehicle size, weight, development and life cycle costs.

W92-70112 **(62) 590-21**
Marshall Space Flight Center, Huntsville, AL.
EARTH TO ORBIT
J. L. Moses 205-544-1747

The objectives are to extend and further develop the earth-to-orbit propulsion technology base in support of current and future space transportation systems. The described technology encompasses oxygen/hydrogen, oxygen/hydrocarbon propulsion and is directed at enhancing engine life, performance and operability. The activity is divided into two categories: O2/H2 technology acquisition and O2/H2 technology validation. Technology acquisition activities include analytical model development, performance improvement, cold flow testing, combustor cooling, turbine drive gas generation, control system analysis, materials and process synthesis, and advanced instrumentation development. The technology verification effort is subdivided into three areas: large-scale turbomachinery components, controls, and monitoring subsystems. The technology advancements arising from the technology acquisition activity will receive a final degree of verification by testing on a large-scale component, control and monitoring subsystem or on the oxygen/hydrogen engine system testbed.

W92-70113 **(64) 590-21**
John C. Stennis Space Center, Bay Saint Louis, MS.
EARTH TO ORBIT
D. J. Chenevert 601-688-3126

The objective of this RTOP is to provide for research and development of three key engine test technologies. The technologies developed will help fulfill requirements for component test, engine development, and testing and will provide for the safe and cost effective conduct of these activities. Programs benefiting from this initiative include the Space Transportation Main Engine (STME), National Launch System (NLS), and other advanced programs. The activities sponsored by this RTOP include an extension of SSC's current engine diagnostic programs through basic research into the spectroscopic processes of combustion and rocket plumes and the integration of new spectroscopic processes with advanced interconnects, algorithms, and control logic. This activity ultimately provides for the development of more effective engine health monitoring sensors. Other activities include technical review and evaluation to the Robust High Pressure Propellant Pump system conceptual design, final design and development program (system development funded under Code MD). The robust pump systems will be designed to support the testing of engine components by long duration pumping LOX, LH2, and storable propellants.

Science

W92-70114 **(21) 590-31**
Ames Research Center, Moffett Field, CA.
SCIENCE SENSOR TECHNOLOGY
C. R. McCreight 415-604-6549
(506-59-00)

Advanced infrared (IR) detector array technology, and advanced detection concepts which promise to provide future IR arrays, will be developed and characterized. These arrays will be applicable in low and moderate background missions such as the Space Infrared Telescope Facility (SIRTF), Submillimeter Moderate Mission (SMMM), and the Large Deployable Reflector (LDR). The goal is to achieve enhanced IR spectral response (to and beyond 200 micrometers) and improved sensitivity in anticipated orbital environments. Advanced low-noise multiplexer, impurity band conduction, and improved long-wavelength array technology will be pursued. A second objective is to develop and demonstrate advanced cryogenic systems for future space applications. These coolers are required to have a high efficiency, low cost, an extended life, and good temperature stability. In some applications the coolers must allow the instruments to be serviced and/or replaced on orbit. Elements of this objective include pulse tube refrigerators, a 2 to 15 K cooler, and advanced coolers for less than 1 K operation. These activities blend analysis with component development, and include extensive in-house characterization, development, and technology demonstrations.

W92-70115 **(23) 590-31**
Langley Research Center, Hampton, VA.
SCIENCE SENSOR TECHNOLOGY
F. Allario 804-864-6027

The objective is to develop all solid-state components for versatile active remote sensors supporting high-flying aircraft and space-based earth science investigations in atmospheric dynamics and chemistry. The most important of these sensors are Light Detection and Ranging (LIDAR), Differential Absorption Lidar (DIAL), and Doppler Heterodyne Systems. This research and technology program was structured to approach these challenges in the areas of laser materials research, detector materials research, laser transmitter design and development, discrete and array detector design and development, lifetime and efficiency improvement through in-house, university grant, and industrial contract efforts.

W92-70116 **(51) 590-31**
Goddard Space Flight Center, Greenbelt, MD.
SCIENCE SENSOR TECHNOLOGY
Henry H. Plotkin 301-286-6185
(506-59-41; 506-59-51)

Technology for Earth and Space Science orbital missions is developed in the areas of Lidar and Sensor Cooler Systems. Advanced electro-optics and laser technologies are developed for spaceborne laser ranging and altimetry earth science applications on EOS. The Geoscience Laser Ranging System (GLRS) is designed to provide geoscience measurements requiring extremely accurate geodetic observations from a spacecraft. The GLRS facility instrument uses state-of-the-art picosecond pulse lasers in space to sense the position of cooperative retroreflector targets on the earth's surface. The instrument employs the technique of pulse time-of-flight measurement to determine the distance between the satellite and target. In the altimetric mode, relative height determinations will be obtained with a nadir-looking Q-switched, nanosecond pulse solid state laser transmitter and range-gated receiver. Long-life, vibration-free, efficient cryogenic cooler systems are being developed to meet requirements of a number of new sensing instruments which must operate at temperatures ranging from 65 K to as low as 2 K. Tasks include flexure and magnetic bearings, multistage coolers, and new concepts for efficient regenerative cycles.

W92-70117 **(55) 590-31**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
SCIENCE SENSOR TECHNOLOGY
V. Sarohia 818-354-6758
(506-59-00)

The objective is to develop enabling sensor technologies for future NASA space missions such as SIRTF, EOS, SMIM, LDR, etc. One of the goals is to develop a space qualifiable submillimeter heterodyne receiver. The enabling components are: (1) mixer elements; (2) local oscillators; and (3) tuning and embedding structures operating in the frequency range 300 to 3000 GHz. The mixer element for astronomy applications is a Superconductor/Insulator/Superconductor (SIS) tunnel junction based on the niobium and niobium nitride materials systems. Single elements and arrays of elements will be developed. Planar mixers using gallium arsenide will be developed for the EOS Microwave Limb Sounder (MLS). The local oscillator effort develops novel devices and demonstrates performance in the THz range. The other major objective is to demonstrate new options for infrared detector arrays that can enable or significantly enhance future missions. The approach consists of the following tasks: (1) silicon compatible sensors using MBE-engineering of silicon-based materials and structures to achieve sensitive and large format detector arrays with response to 17 um; (2) III-V based LWIR detectors using MBE-engineering of III-V materials and detector structures to achieve monolithic detector arrays with response to 18 um; (3) Germanium-Blocked Impurity-Band (GeBIB) detector arrays using CVD growth technology to achieve sensitive, low noise response at cryogenic temperatures for far-infrared (30 to 250 um) instruments; and (4) advanced thermal detectors and arrays, based on tunnel sensor Golay cells and silicon micromachining, to achieve broadband response (especially from 18 to 300 um) with at least a factor of ten improvement in sensitivity over current detectors using only passive cooling (greater than 70K).

W92-70118 **(62) 590-31**
Marshall Space Flight Center, Huntsville, AL.
SCIENCE SENSOR TECHNOLOGY
J. B. Haussler 205-544-1762

Research for applying CO2 lasers to spaced-based lidar applications will be conducted. The primary benefitting program will be the Laser Atmospheric Wind Sounder (LAWS) instrument. The approach incorporates research from groups at LaRC, JPL, MSFC, NOAA/WPL, and industry.

W92-70119 **(21) 590-32**
Ames Research Center, Moffett Field, CA.
HIGH RATE/CAPACITY DATA SYSTEMS
H. Lum 415-604-6544
(595-12-00)

The objective is to develop the architectural infrastructure to enhance the performance of heterogeneous, distributed computer systems. This work will focus on: (1) improved hardware and software architectures for the handling of large scientific data flows resulting from current and planned NASA missions through the integration of advanced processor technologies (e.g., neural network), and data and hardware management concepts (parallel processing algorithms and fault management); and (2) development of prototype architectures to evaluate and validate the proposed concepts. The architectural infrastructure includes the integration of the Center for Advanced Data Evaluation Technology (CADET) with Division testbed resources to develop, implement, and test new data management concepts against real world hardware and data flow constraints. Efforts would be tightly coordinated with GSFC and non-NASA agencies (e.g., DARPA) to provide advanced architecture concepts, both hardware and software, and validated in the Ames Advanced Data Systems and Software Test Facility.

W92-70120 **(23) 590-32**
Langley Research Center, Hampton, VA.
HIGH RATE/CAPACITY DATA SYSTEMS
F. Allario 804-864-6027
(506-59-00; 505-64-00)

The objective is to research new concepts in space data processing and storage. This concept development will result in planning, development, and delivery of technology research and development studies, system feasibility models, and prototype proof-of-concept hardware in support of NASA's mission, including Advanced Aerospace Transportation Vehicles, Space Station, Co-orbiting Platforms, Polar-orbiting Platforms, and Deep Space Payloads, in the areas of Data Systems. The approach is to use mission identified needs and analysis, together with new device and systems technologies in high-speed, space-qualified processors, and high-rate/capacity optical storage systems, to provide an enabling and enhanced system level performance. In particular, elements will be researched and developed through the proof-of-concept phase, and this technology will be delivered for mission projects where appropriate. Individual tasks included are: VHSIC Processor Technology, Erasable Optical Media, Laser Diode Arrays, Multichannel Controller, Optical Disk Drive, and Fiber Optic Integrated Circuit Transceivers.

W92-70121 **(51) 590-32**
Goddard Space Flight Center, Greenbelt, MD.
HIGH-RATE/CAPACITY DATA SYSTEMS
J. Dalton 301-286-8623

The objective is to develop an onboard high rate/high capacity data system called the Configurable High Rate Processing System (CHRPS) suitable for onboard spacecraft processing of space and Earth sciences sensor data. The CHRPS capabilities will be adaptable to the needs of different instruments and missions by reconfiguring in real time to adapt to changes in the operating environment. The architecture will adapt to support a range of

high data rate imaging missions and will support evaluation of higher levels of onboard data compression, analysis and instrument control through development of onboard processor and storage technology. CHRPS will be coordinated with the definition of the next generation of high rate imaging missions and will provide the total onboard data management support required for scientific operations from instrument interface to communication link transmitters and receivers. This includes all formatting, coding, buffering, processing, editing, storage, and multiplexing required by complex heterogeneous payloads operating from ten to hundreds of megabits per second. The integration of technology components from other centers in the CSTI Data Systems Program into a testbed demonstration focused on compression and management of data from EOS.

W92-70122 **(55) 590-32**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
HIGH RATE/CAPACITY DATA SYSTEMS
Michael D. Henry 818-354-1706
(506-59-00)

The objective and approach of this RTOP is to provide research and technology development for specific high rate and high capacity space flight data system components. This RTOP is part of the Civil Space Technology Initiative (CSTI) Data Systems: High Rate/Capacity Program and will be managed in accordance with the Office of Aeronautics, Exploration and Technology (OAET) program plan. Data system technology development included in this RTOP will both enhance the ability to make productive scientific use of collected data and enable the deployment of instruments to make new and unique observations. Specific tasks include the development and demonstration of: (1) Common Space Multicomputer Operating System; (2) a spaceborne processor capable of radiometric calibration, compression, and information extraction as applied to imaging spectrometer data; (3) an autocorrelation spectrometer suitable for use in spaceborne mm-wave and submm-wave radiometers; and (4) high-density solid state nonvolatile random access and block access memory and storage devices. In these tasks the goal will be the development of a flight qualifiable prototype which could form the basis of an actual operational or experimental unit in the Earth Observing System (EOS) program or in other missions.

Exploration Technology Program

Space Transportation

W92-70123 **(22) 593-12**
Lewis Research Center, Cleveland, OH.
SPACE-BASED ENGINES
L. A. Diehl 216-433-2438

The goal is to provide the technology necessary to confidently proceed, in the late 1990's, with development of moderate-thrust (7.5 to 200 Klbf) high performance liquid oxygen/liquid hydrogen expander cycle engines for various space transportation applications. Major objectives include: (1) identification and assessment of technology requirements; (2) identification, creation, and/or validation of design and analysis methodologies, materials with required properties, and reliable, cost-effective manufacturing processes; (3) development and validation of engine subcomponent, component, subsystem, and system technologies focused on improved performance, durability, reliability, and operational efficiency, reduced cost; and (4) development and validation of technologies for operationally-efficient propulsion system. The approach includes propulsion studies to define technology requirements and technology efforts addressing the above objectives. The overall effort is centered around the Advanced Expander Test Bed (AETB) in which the developed technologies and hardware designs will be validated in a systems environment.

Human Support

W92-70124 **(55) 593-41**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
REGENERATIVE LIFE SUPPORT
P. K. Seshan 818-354-7215

The objectives of this RTOP are: (1) to continue the scope of work described in former RTOP No. 591-34 and hence provide systems analysis and assessment support to the Office of Aeronautics, Exploration and Technology (OAET) in the area of physical-chemical (P-C) closed-loop life support, and develop sensor technology for autonomous and fault-tolerant operation of Life Support Systems (LSS); (2) to increase the scope of work described in former RTOP by including air revitalization technologies recommended by JSC and water treatment technologies being studied at ARC, adding hardware redundancy and leak rate options to the systems analysis model, adding an option to plot validity level distributions, initiating research at JPL in the area of multifunctional in-situ chemical and biological sensors, establishing collaborative efforts among industry, academia and Government laboratories engaged in chemical and biological in-situ sensor research and development, and initiating the development of hierarchical integration of in-situ sensors in the context of autonomous control of LSS; and (3) to continue the subcontract for expert technology assessment of extant life support technologies.

W92-70125 **(72) 593-41**
Lyndon B. Johnson Space Center, Houston, TX.
REGENERATIVE LIFE SUPPORT
H. E. Winkler 713-483-9255
(506-71-00)

The objectives of this RTOP effort are to provide the technology base required to sustain human life throughout long-duration space missions that will explore the solar system. The technical approach is based on a dual-path strategy which combines process, subsystem, and systems-level computer modeling and analysis with technology development and systems-level testing. This approach will be applied to select and develop physiocochemical technology candidates for use in primary life support subsystems for air revitalization, thermal control, and water reclamation. Emphasis in FY-92 will be directed to system-level testing in conjunction with technology development. Subsystem/systems-level analyses and assessments will be performed to assist in guiding and directing the overall effort.

W92-70126 **(23) 593-42**
Langley Research Center, Hampton, VA.
RADIATION PROTECTION
W. Ray Hook 804-864-6055
(199-04-00)

The Space Radiation Protection project of the Exploration Technology Program develops the technologies and strategies necessary to efficiently protect astronauts from radiation during extended missions, largely beyond the Earth's magnetosphere. Space radiation includes galactic cosmic rays, solar particle events, and trapped radiation. This project supports development of extended habitation of the lunar surface and long-range, manned-roving, and piloted vehicles to Mars. Its objectives are to: (1) establish a data base of shielding-material properties; (2) develop an accurate, laboratory validated computer code for determining the radiation exposure to crew members behind a shield; (3) define shield conceptual designs and shielding strategies

which illustrate efficient radiation protection; and (4) develop and characterize both structurally and in test radiation, practical technology breadboard shields. The project includes laboratory measurements to establish materials properties, including structural atomic and nuclear data, computer code development, preliminary design studies, and breadboard shield fabrication and testing. Radiation measurements performed at DOE National Laboratories define projectile/target transport and cross sections in support of code development and validation, shield conceptual designs, and for shield panel testing.

W92-70127 **(21) 593-43**
Ames Research Center, Moffett Field, CA.
EXTRAVEHICULAR ACTIVITY SYSTEMS (SURFACE)
B. Webbon 415-604-6646
(506-71-00)

Astronauts on lunar and planetary missions will require an extravehicular activity (EVA) work system consisting of a pressure suit, life support system, and ancillary equipment allowing them to move and work comfortably, easily, and efficiently. The system must be rugged, reliable, and impervious to dust and other damaging conditions found in planetary surfaces and atmospheres, and serviced quickly and easily while requiring minimal resources. In the near term, systems studies are required to define mission environments, a reference mission, exploration mission tasks, and task requirements. Efforts will be initiated to develop the technology for a reliable, highly-mobile, routinely-serviceable EVA suit with compact, fully regenerable portable life systems. Identification of suit structural materials and design of a highly dexterous EVA glove are foreseen. Efficient processes for provision of breathable air and removal of waste from expired air as well as the on-board regeneration of waste will be developed. New concepts in thermal management, personal mobility concepts, and information display and control capabilities for the suited astronaut will be provided. Determining technology needs for tools, end-effectors, and communications will be completed. In the longer term, technologies will be integrated into one or more advanced, lightweight suits and portable life support system (PLSS) prototypes and tested extensively in ground-based facilities in preparation for flight testing.

W92-70128 **(72) 593-43**
Lyndon B. Johnson Space Center, Houston, TX.
EXTRAVEHICULAR ACTIVITY SYSTEMS (SURFACE)
James W. McBarron, II 713-483-9254
(591-34-00; 506-41-00)

The objective of this RTOP effort is to continue the development of analytical and hardware technologies necessary to enable humans to perform extravehicular activity (EVA) productively and efficiently in the hostile environments of the Moon and Mars. This effort will concentrate on four technology areas: (1) human requirements definition, emphasizing human factors; (2) EVA systems integration modeling and trade studies; (3) portable life support subsystems thermal control, emphasizing heat rejection, and atmosphere control subsystems; and (4) space suit technology, emphasizing lightweight structural materials and dust protection techniques. The research in all of these areas will encompass the gathering of fundamental process data necessary to develop the analytical models required for the EVA systems integration, heat rejection technologies, space suit materials, and human factors in order to conduct supporting trade studies and system analyses.

Nuclear Propulsion

W92-70129 **(22) 593-71**
Lewis Research Center, Cleveland, OH.
NUCLEAR THERMAL PROPULSION
T. J. Miller 216-977-7102
(593-72-00)

The objective of the Nuclear Propulsion Project is to develop and demonstrate technology readiness for safe and reliable nuclear propulsion systems to support piloted missions to the Moon and Mars and return safely to Earth. Space Exploration Initiative (SEI) requirements will drive definition of candidate nuclear propulsion concepts, and these concepts will direct the enabling technology. Reference propulsion system designs will be developed early in the project to define the component and subsystem configurations, to permit development of system technologies for nuclear propulsion, and to permit the selection of a propulsion system for further development that will satisfy the SEI requirements for Moon and Mars cargo and piloted missions. The approach for Nuclear Thermal Propulsion (NTP) will include conceptual design, enabling and innovative technology development, safety and environmental studies, a proactive public perception program, and facility definition and environmental impact studies. NTP technology development will be through technology readiness 6 - full system ground testing. This effort will be funded jointly by DOE and NASA. The technology development will be conducted by a team consisting of NASA Centers, national laboratories, industry, and academia. Each organization will contribute in the areas of their respective expertise.

W92-70130 **(62) 593-71**
Marshall Space Flight Center, Huntsville, AL.
NUCLEAR THERMAL PROPULSION
M. S. Swint 205-544-4060

Nuclear Thermal Propulsion (NTP) is one of the two elements, or projects, of the Nuclear Propulsion Thrust of the Exploration Technology Program. NTP offers the potential for significant reductions in mission trip times or initial mass in low Earth orbit requirements compared to chemical propulsion systems. The Nuclear Engine for Rocket Vehicle Applications (NERVA) derived solid-core reactor was pursued extensively and achieved very successful ground test demonstrations. Other, more advanced, concepts were also explored during this period. The Nuclear Propulsion Project Office (NPPO) has identified three concurrent paths for the NTP program: concept definition and selection; reactor fuel development; and enabling facilities development. Within the objectives of the NPPO, MSFC will conduct research and analysis consistent with MSFC strengths and capabilities that will advance those technologies relative to the non-nuclear components and subsystems. Areas to be addressed will include, but not be limited to, feed system including ducts, lines, valves, turbomachinery and turbomachinery sub-components, propellant tankage, controls, non-nuclear materials, and nozzles. Selected technologies relative to nuclear fuels and materials will be conducted. These objectives will be met through concept definition studies, facilities definition and development, analytical and experimental work to characterize materials and subsystem, component and subcomponent research and modeling.

W92-70131 **(22) 593-72**
Lewis Research Center, Cleveland, OH.
NUCLEAR ELECTRIC PROPULSION
T. J. Miller 216-977-7102
(593-71-00)

The objective of the Nuclear Propulsion Project is to develop and demonstrate technology readiness for safe and reliable nuclear propulsion systems to support piloted missions to the Moon and Mars and return safely to Earth. Space Exploration Initiative (SEI) requirements will drive definition of candidate nuclear propulsion concepts, and these concepts will direct the enabling technology. Reference propulsion system designs will be developed early in the project to define the component and subsystem configurations, to permit development of system technologies for nuclear propulsion, and to permit the selection of a propulsion system for further development that will satisfy the SEI requirements for Moon

and Mars cargo and piloted missions. For Nuclear Electric Propulsion (NEP), full system application for an Office of Space Science and Applications planetary robotic science mission is also being investigated. The approach for NEP will be evolutionary, focusing first on early applications for robotic missions at submegawatt power levels, then on megawatt class cargo applications, and finally on manned Mars missions at 10's of megawatts. The approach will include conceptual design, enabling and innovative technology development, safety and environmental studies, a proactive public perception program, and facility definition and environmental impact studies. NEP will be taken through technology readiness 5, subsystem ground testing (but not a full up system ground test). For NEP, full system application for a Code S planetary robotic science mission is also being investigated. This effort will be funded jointly by DOE and NASA. The technology development will be conducted by a team consisting of NASA Centers, national laboratories, industry, and academia. Each organization will contribute in the areas of their respective expertise.

W92-70132 **(55) 593-72**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
NUCLEAR ELECTRIC PROPULSION
P. W. Garrison 818-354-3575
(506-42-00)

For ambitious robotic and piloted missions planned in support of human exploration of the Moon and Mars, high power (0.5 to 100 MWe) nuclear electric propulsion (NEP) offers substantial benefits. The work performed under this RTOP, which is coordinated with the NASA Nuclear Propulsion Project work plan, reflects early emphasis on the highest priority issues. Innovative NEP technologies are studied to identify advanced plasma acceleration schemes which promise large benefits relative to existing (ion and magnetoplasmadynamic (MPD)) thruster concepts for large, multi-megawatt NEP systems.

Space Automation and Telerobotics

Telerobotics

W92-70133 **(21) 595-11**
Ames Research Center, Moffett Field, CA.
TELEROBOTICS
H. Lum 415-604-6544
(595-12-00)

The objective is to develop and test integrated knowledge-based systems including real-time control and human/machine interfaces for mobile intelligent space robotic systems which will obtain the maximum level of productivity from an astronaut team. Through the development and use of intelligent robots, a single human will be able to accomplish a larger set of complex tasks rather than concentrate on and execute repetitive, labor-intensive tasks. Current emphasis is on the real-time control and task planning for mobile, cooperating, intelligent two-arm Satellite Robot Simulator Vehicles (SRSV) and on the development of object-level control and operator interfaces. The basic SRSV systems research is being conducted at the Stanford University Aerospace Robotics Laboratory in collaboration with DARPA, DOD, NSF, and industry. Current research elements include: object-level control and operator interfacing, cooperative manipulation; simultaneous control of a quick minimanipulator and the very flexible arm that carries it; free flying space robot navigation and locomotion; multiple-robot team cooperation; control of very flexible, multi-link manipulators; and load-adaptive control in each of the above. A research effort has also been established with Stanford University Department of Computer Science to integrate the artificial intelligence research with the robotics research with emphasis on the development of intelligent cooperating robots.

W92-70134 **(23) 595-11**
Langley Research Center, Hampton, VA.
TELEROBOTICS
J. F. Creedon 804-864-6033

The objective of the activity is to provide automated manipulator, mobility, sensing, and actuation technology needed for future NASA teleoperation and robotics applications such as satellite servicing, maintenance and repair, structural assembly, and space manufacturing. The development and evaluation of noncontact sensing/processing are additional objectives of this research. The approach is to conceptualize, evaluate, and verify algorithms, sensors, actuators, software, and system architecture required for remote space operations. The research will be conducted through simulation and laboratory hardware experimental tests. Current plans are: (1) to investigate cooperative human/machine control of compound and redundant manipulator systems and to augment the human teleoperator control through the application of advanced control technology to automate the system, elevating the operator to higher levels of supervisory control; and (2) to develop and apply sensing, planning, and control methods to enable realistic robotic tasks under remote supervision.

W92-70135 **(51) 595-11**
Goddard Space Flight Center, Greenbelt, MD.
TELEROBOTICS
J. Azzolini 301-286-3606

As the costs and hazards associated with astronaut extravehicular activity (EVA) increase, robot manipulators will be increasingly relied upon to perform spacecraft servicing operations. NASA's Earth Observing System (EOS) polar orbiting platform will be designed and built to facilitate in-orbit servicing. EOS instrument calibration, inspection and orbital replacement unit (ORU) exchange are servicing tasks that can support the mission science objectives and possibly increase the life of the spacecraft. Currently, there are no plans to provide astronaut presence in polar orbit. The EOS project is currently funding studies to determine servicing requirements, feasibility, concepts, platform impacts and costs associated with a robotic servicing system used for instrument calibration. The aim of this RTOP is the in-house demonstration of an autonomously controlled manipulator system that can perform instrument calibration, alignment and ORU exchange tasks while traversing a simulated EOS platform.

W92-70136 **(55) 595-11**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
TELEROBOTICS
Charles R. Weisbin 818-354-2013
(488-90-00; 486-86-00; 906-30-00)

The general objective is to develop a new generation of telerobot system technologies and to show their value to prospective users. Teleoperation is the baseline, with some automated tasks done under manned supervision as needed. The program is focused about four space system paradigms: (1) mobile robotics for surveillance and manipulation via remotely piloted roving vehicles in the 1 to 1000 kg class (example applications are science sample acquisition, surveys, and deployment of instrumentation); (2) telerobotics inspection to assist the astronaut and controller crew in finding space system surface and configuration flaws and anomalies; (3) advanced teleoperation to deal with complicated one-of-a-kind operations including exoskeleton with visual and kinesthetic sensing to enrich manual dexterity and increase telepresence in teleoperation; and (4) terrestrial robotics applications: emergency response vehicle to maximize human safety in dangerous terrestrial situations; and satellite test assistance to assit in spacecraft system testing in calibrated thermo-vacuum environments through applications of telerobotic technology. In all the paradigms, system capabilities are developed for needs for specific users; close interactions exist with users at all phases of technology development.

W92-70137 **(72) 595-11**
Lyndon B. Johnson Space Center, Houston, TX.
TELEROBOTICS
C. R. Price 713-483-1523

The objectives of the Robotics Program element are to perform research in advanced robotics regarding fault tolerant manipulator systems. For space operations, extraordinary reliability will be needed to protect space assets, and to ensure that robots are capable of physical task performance over long duration missions. The goal of the Fault Tolerant Joint Development task is to design and develop a redundant manipulator joint mechanism concept and control strategy which will incorporate the ability to transparently absorb control or mechanism failures and maintain stable joint control with minimum disturbances. The goal of the Failure Tolerance in Manipulator Design task is to develop a major testbed to treat failure tolerance in mechanical structures associated with robotics and computer controlled machines. Three levels of failure tolerance in the mechanical structure and similar controlling software will be developed based on criteria based decision making in a finite fault tree to operate the system to avoid faults in real time. The objectives of the Teleoperations program element are twofold. The first is to provide a robotic emulation of the Canadian Special Purpose Dexterous Manipulator (SPDM) and perform candidate Orbital Replacement Unit (ORU) experiments. This system will provide the capability to assess Space Station Freedom's (SSF) compatibility with planned robotic maintenance. Through a high fidelity model of this type, an accurate assessment of SSF robotic maintenance capabilities can be achieved. From this information, critical design inputs can be made early in the development cycle. The second objective of the Teleoperations program element is to demonstrate advanced closed loop control by application of OAST developed force/torque sensor and control algorithms to the Shuttle Remote Manipulator System (RMS) in order to influence future RMS upgrades. A new application of the force-controlled RMS will be demonstrated. The application is to use the Force-controlled SRMS to aid the assembly of objects through the use of an active compliance mode. The approach will be to demonstrate the active compliance mode using the 1-G SRMS trainer (MDF) and force control laws developed in a previous RTOP.

W92-70138 **(76) 595-11**
John F. Kennedy Space Center, Cocoa Beach, FL.
TELEROBOTICS
E. L. Rhodes 407-867-2780

The objective of this RTOP is to demonstrate the use of robotics technologies to solve specific problems in NASA launch vehicle and payload processing operations at Kennedy Space Center. The primary project goal is to introduce, within two to three years, robotic applications into those areas that will improve operations efficiency as well as increase safety, quality, and reliability. This goal will be accomplished by implementing the results of FY-90 studies to focus the appropriate technology into realistic operations areas which are supported by the user. Production qualified prototype hardware will be developed to demonstrate feasibility to the user community. This hardware will be sufficiently robust to enable the user to develop confidence in using robots around space hardware. A secondary goal is to demonstrate, on the ground, the feasibility and robustness of robotics that may be used in space. This work will be carried out by both in-house and contracted companies, universities, and others as needed. Tasks will be directed by the KSC Advanced Systems and Technology Office and will be conducted by engineers in coordination with personnel from vehicle operations, payload operations, facility operations, other NASA centers, university communities, and contractors. The designs selected are the ones analyzed as the most appropriate for high payoff and initial project success. The projects will minimize technical risk by maximizing use of existing robust components. This will improve the efficiency and reliability, and reduce costs of the current KSC launch vehicle and payload processing tasks. In addition, the selected concepts are applicable to development of more advanced autonomous systems for both Space Station and future launch vehicle ground operations.

Artificial Intelligence

W92-70139 **(21) 595-12**
Ames Research Center, Moffett Field, CA.
ARTIFICIAL INTELLIGENCE
H. Lum 415-604-6544

The objective of the artificial intelligence research program is to develop, integrate, and demonstrate the science and technology of artificial intelligence (AI) that will lead to increasing the operational capability, safety, cost effectiveness, and probability of success of NASA missions. AI applications to these missions fall into four basic categories: intelligent assistance for humans involved in ground and space-based mission operations; tools and techniques to aid in the analysis of scientific and engineering data; autonomous, on-board, fault diagnosis, correction, and control of spacecraft systems; and, capture, integration, and preservation of life-cycle knowledge. The approach of the ARC program has been to develop a world-class internal laboratory in collaboration with an academic/industrial team of leading scientists and engineers. The program includes basic research in machine learning, planning and scheduling, and design of and reasoning about large-scale physical systems. It also encompasses specific applications projects in the area of intelligent assistants to human problem-solving as well as many applications spin-offs from the basic research tasks. All of the research and development work is being leveraged by close cooperation with other leaders in the U.S. government, particularly DARPA's Information Sciences Technology Office (ISTO).

W92-70140 **(22) 595-12**
Lewis Research Center, Cleveland, OH.
ARTIFICIAL INTELLIGENCE
H. W. Brandhorst 216-433-6149
(488-51-03; 549-03-00)

The objective is to provide technology development support for application of knowledge-based systems (KBS) to the Space Station Freedom Electrical Power System (SSFEPS) and other complex manned systems. This objective specifically includes: (1) development/application of appropriate KBS architectures to the SSFEPS; (2) development/adaption of KBS tools to the SSFEPS; and (3) investigation of cooperative problem-solving considerations between knowledge-based power systems and other intelligent agents. An additional objective is to resolve issues involved in application/transfer of autonomous power systems technology from the SSFEPS to other large complex aerospace electrical power systems. The approach will be to develop an Automated Power Expert (APEX) expert system consisting of fault management and power/energy scheduler software along with appropriate control interfaces, and demonstrate its operation on appropriate power testbed facilities. This is a cooperative program between OAET and the Office of Space Flight (OSF). The OAET emphasis is on development/application of KBS software tools, while the OSF is on support for testbed/control system interfacing and Space Station global integration considerations.

W92-70141 **(51) 595-12**
Goddard Space Flight Center, Greenbelt, MD.
ARTIFICIAL INTELLIGENCE
J. Dalton 301-286-8623

The overall objective is to research and develop the basic technologies of knowledge-based systems required to achieve successfully higher levels of autonomous activity in command and control systems both on the ground and in space. The immediate testbed for these technology developments will be near-earth

spacecraft control ground/space systems. The general approach will be to develop and demonstrate the concept of an Intelligent Control Center (ICC). This testbed will incorporate multiple knowledge-based ground operations system components which operate in a coordinated and cooperative fashion to achieve operational system objectives. The focus of the testbed will be the Earth Observing System (EOS) ground systems.

W92-70142 **(55) 595-12**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
ARTIFICIAL INTELLIGENCE
Richard J. Doyle 818-354-6476
(510-40-73; 656-65-21)

This RTOP describes all work being performed at JPL as part of the NASA OAET Artificial Intelligence Program. The main objectives are: (1) to apply and extend mature AI technologies in the areas of scheduling, monitoring, diagnosis, design, data analysis, software reuse, and infrastructure, and demonstrate technology readiness for addressing current mission operations and scientific data analysis needs; and (2) to push the state-of-the-art in AI in scheduling, planning, model-based reasoning, and machine learning to address long-term JPL and NASA needs. The objectives of the Artificial Intelligence RTOP will be met by: (1) developing and demonstrating monitoring and control technology for ground data systems in Flight Project and Deep Space Network operations; (2) providing capabilities for generating schedules for over-subscribed domains and accommodating changes in tasking or resources in a minimally disruptive manner; (3) applying AI techniques to software classification and retrieval through hypermedia interfaces; (4) developing AI-based software tools of support scientists in the preparation, accessing, and analysis of large scientific data sets; (5) applying knowledge-based and hypermedia technology to an infrastructure application; and (6) generating and evaluating AI-based methods to support real-time sensor interpretation during monitoring and evaluation of sensor placements during design for complex systems.

W92-70143 **(62) 595-12**
Marshall Space Flight Center, Huntsville, AL.
ARTIFICIAL INTELLIGENCE
J. B. Haussler 205-544-1762

The Space Station Module/Power Management and Distribution (SSM/PMAD) task consists of three expert systems that must cooperate to control a single subsystem, namely a power distribution subsystem. These expert systems need to understand each other well enough to work together in solving problems while avoiding stalemate conditions. This intelligent subsystem also has to understand and interact with the human operator. The objective of this task is to make one or more of the expert systems smart enough to understand how to interact with the others as well as with the human operator. This objective may be partially accomplished with smart front ends and interfaces. A blackboard architecture, called the Knowledge Management Design (KNOMAD) System, has been successfully implemented as one approach to the problem. A related issue to the multiple interactive expert systems is that of having the expert systems closely interact with the conventional software. Therefore, since NASA programs involving artificial intelligence (AI) will, in many cases, require the expert system(s) to be closely coupled to embedded conventional software programs and to the human operator, a successful completion of this task should affect many NASA programs.

W92-70144 **(72) 595-12**
Lyndon B. Johnson Space Center, Houston, TX.
ARTIFICIAL INTELLIGENCE
K. J. Healey 713-483-4776

The objectives of this RTOP are to continue and expand the appropriate application of artificial intelligence, in the areas of (1) ground operations, (2) software performance testing, (3) project scheduling, and (4) assistance and guidelines for design of intelligent systems and their human interfaces for effective human interaction. The approach for (1) is to continue placing realtime expert systems into mission control to perform telemetry monitoring and subsystem fault diagnosis. The approach for (2) is to develop and apply artificial intelligence technologies to mission - critical Space Shuttle flight software regression test analysis. The approach for (3) is to enhance the COMPASS (Computer Aided Scheduling System) scheduling tool to provide resource constrained project scheduling capabilities. The approach for (4) is to continue and refine the identification of design processes and application constraints, lessons learned, design issues, and candidate guidelines and helpful examples for intelligent systems and their human interfaces.

W92-70145 **(76) 595-12**
John F. Kennedy Space Center, Cocoa Beach, FL.
ARTIFICIAL INTELLIGENCE
A. E. Heard 407-867-2780

The objective of this RTOP is to provide technology development support for application of knowledge based systems to Space Transportation System (STS) processing at Kennedy Space Center. The project goal is to emulate the existing distributed processing system used for the KSC Launch Processing System (LPS) by demonstrating a distributed set of knowledge-based systems cooperating to provide system analysis, fault monitoring, diagnosis, and task planning and scheduling support for STS processing operations. This goal will be accomplished by production of a distributed architecture shell allowing integration of independently developed intelligent applications into a unified intelligent operations support tool sharing resources such as real-time data and knowledge base access. Knowledge based systems to be included in this environment are capabilities for automated planning and scheduling as well as the Knowledge Based Autonomous Test Engineer (KATE) advisory system shell which will be refined to support additional vehicle subsystems. This resulting demonstration environment, the Expert System for Operations Distributed Users (EXODUS), will facilitate deployment of intelligent systems for KSC operations support by streamlining data interface requirements, allowing incremental application additions and offering a low risk vehicle for validation and assessment of value-added automation enhancements offered by the various knowledge-based systems. Incorporation of project goals should improve the efficiency and reliability and reduce costs of the current KSC launch processing tasks to better accommodate planned launch rate increases. In addition, project developed concepts are applicable to development of autonomous systems for both Space Station and future launch vehicle ground and on-board systems.

OFFICE OF SPACE SCIENCE AND APPLICATIONS

Interdisciplinary R&A

W92-70146 **148-90-00**
Ames Research Center, Moffett Field, CA.
REGIONAL CARBON FLUX IN HIGH LATITUDE ECOSYSTEMS
G. P. Livingston 415-604-3232
(463-43-00)

This research addresses the regional-seasonal estimation of carbon flux and the regulatory exchange processes for select northern high latitude ecosystems. This is achieved through integration of in situ flux observations, simulation modeling, and land surface stratifications based upon satellite and aircraft remote sensing. Initial surface observations will determine the magnitude and variability of methane and carbon dioxide emissions along select environmental gradients to characterize the regulatory biogeochemical processes. Net emissions will be estimated within ecological spatial strata derived from several spectral imaging

sensors. Various estimation approaches of regional flux will be assessed based upon chamber, eddy correlation, and isotopic analyses of gas emissions; sampling and geostatistical theory; and the remote sensing derived strata. Surface flux measurements coupled with multitemporal coregistered Advanced Very High Resolution Radiometer (AVHRR) data will provide the basis for an assessment of the seasonal variability of carbon flux for Arctic tundra ecosystems. Various sources of error in the regional-seasonal estimates will be identified and their contribution to the overall estimated precision evaluated. The significance of high latitude ecosystems in the global carbon budget will be addressed through atmospheric modeling using existing photochemical models developed at Ames Research Center (ARC).

W92-70147 **148-90-00**
Goddard Space Flight Center, Greenbelt, MD.
INTERDISCIPLINARY RESEARCH IN EARTH SCIENCES
H. Jay Zwally 301-286-8239

This RTOP covers interdisciplinary research in the earth sciences including: (1) the role of the hydrologic cycle in atmosphere surface interactions; and (2) detection of changes and identification of forcings due to the greenhouse effect in the climate system.

W92-70148 **148-90-00**
Goddard Inst. for Space Studies, New York, NY.
REMOTE SENSING OF NATURAL WETLANDS
Inez Fung 212-678-5590

The objective of this RTOP is to explore the feasibility of monitoring the global seasonal distribution of natural wetlands by remote sensing techniques. Dr. B. Choudhury of Code 624 has obtained global distributions of the monthly brightness temperature from 1979-1984 from dual-polarized radiation a 37 GHz measured by the Scanning Multichannel Microwave Radiometer (SMMR) aboard Nimbus-7. The brightness temperature has been shown to be a good monitor of soil moisture as well as of vegetation dynamics. We propose to compare the distributions of brightness temperature with a global digital database of wetland ecosystems to explore the ability of the brightness temperature to distinguish natural wetlands. Also, the seasonality of the brightness temperature will be examined against field observations of flooding to test the validity of the timing and areas of seasonal inundation obtained from SMMR data.

W92-70149 **148-90-02**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
VARIATIONS OF GLOBAL SST
D. Halpern 818-354-5327
(578-22-23)

Sea surface temperature (SST) is an important boundary condition of atmospheric circulation. The long-term trend of the global surface air temperature and SST distributions during the past century is about 0.5 C per 100 years. Substantial variations occur between different SST data sets. Over large geographical regions, SST differences of 1-2 C were found between the data sets derived from High Resolution Infrared Sounder (HIRS2) and Microwave Sounding Unit (MSU) (HIRS2/MSU data set) and from ship measurements, Comprehensive Ocean-Atmosphere Data Set (COADS). An objective is to determine if simulated global atmospheric circulations forced with different SST fields statistically different. This research will determine the sensitivity of simulations performed with the University of California/Los Angeles (UCLA) atmospheric general circulation model (AGCM) to global SST distributions compiled monthly from HIRS2/MSU satellite measurements, which have with very little aliasing, and from COADS ship measurements. The multi-decadal COADS SST data set is frequently used as a surrogate of global SST, even though the large amount of aliasing caused by inadequate sampling is well known. If the simulated atmospheric circulations are statistically equivalent, then the reliability of the COADS SST data set for climate studies is enhanced. The UCLA AGCM simulations with COADS and HIRS2/MSU SST data sets prescribed as boundary conditions are being compared with a control run involving only SST climatology. Numerical simulations using the HIRS2/MSU for perpetual January and July 1979 conditions have been completed. Simulations with the COADS data set have recently begun. This research is conducted jointly with Professor C. Roberto Mechoso, UCLA, who is a Co-Principal Investigator. This research is also supported by RTOP 578-22-23.

W92-70150 **148-90-20**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
DETAILEE/RASOOL
D. J. McCleese 818-354-2317

The objective of this RTOP is to provide support to the Earth Science and Applications Division, by the assignment of a Jet Propulsion Laboratory (JPL) detailee to Code S, NASA Headquarters. His primary responsibility will be that of Director of the International Geosphere Biosphere Program (IGBP) Data and Space Information Systems Core Project Office in Paris, France.

W92-70151 **148-90-20**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
EARTH SCIENCE PROGRAM SUPPORT
D. J. McCleese 818-354-2317

The objective of this RTOP is to support the NASA Earth Sciences and Applications Division in: (1) interdisciplinary studies of earth science including mechanisms of climate change, land-air and ocean-atmosphere interactions, and impact of land processes on other earth systems; (2) studying techniques for earth observations; and (3) explore new concepts for earth probe class instrument/missions. Distinguished visiting scientists, including Dr. Robert Dickinson, Professor David Gates and M. Skolnick, will be invited to the Jet Propulsion Laboratory (JPL) for periods of a few weeks to a few months to consult and collaborate with JPL scientists in these studies. Several graduate students will be supported while doing their thesis research at JPL in these interdisciplinary areas. Their research will be directed by JPL science staff members and by the distinguished visiting scientists. Additionally, a one week Earth Science summer school will be conducted.

W92-70152 **148-90-20**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
DISTINGUISHED VISITING SCIENTISTS
M. T. Chahine 818-354-6057

The objective of this RTOP is to provide support to the NASA Earth System Sciences Program in two areas. The first area is the development and application of remote sensing techniques to study surface processes and their interaction with the atmosphere. Science support in this area will be provided with the assistance of Professor R. Goody. In addition, support from M. Ghil, P. Niiler, M. McElroy, and J. Baker will be provided as needed. The level of support could be modified, subject to Code SE and the Jet Propulsion Laboratory (JPL) agreement. The second area is the development of standards for global geophysical data sets. The specific objective is to establish practical criteria for validation, calibration, and long-term stability which can be implemented not only by NASA, but also by international programs such as International Space Year (ISY). Support in this area will be provided by M. T. Chahine in collaboration with specialists at JPL. Recommendation to Code SE will be made in a timely manner to impact NASA activities including Earth Observing System (EOS), Global Energy and Water Cycle Experiment (GEWEX), ISY, and the detection of increased greenhouse effects.

W92-70153 **148-90-27**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
AIR-SEA FLUXES
W. T. Liu 818-354-2394
(578-12-18)

This is a study in response to NASA NRA-88-OSSA-11, IDP 88-017, on the role of the hydrologic cycle in atmospheric-ocean interaction. It is centered on the observations of the Special Sensor Microwave Imager (SSMI) on the operational spacecraft of the

Defense Meteorological Space Program. Monthly evaporation over global oceans will be computed using the sea surface temperature derived from operational infrared radiometers and the wind speed and water vapor derived from SSMI. Each parameter from spaceborne sensors will be evaluated with available in situ measurements and compared with products from atmospheric general circulation models. The wind speed from SSMI will be assimilated into the atmospheric general circulation model (AGCM) at Goddard Space Flight Center (GSFC). The divergence of moisture transport over global oceans derived from analysis fields of AGCM will be examined. Methods to derive the divergence term from satellite observations will be explored. Rainfall derived from satellite data and by the budget method will be used in an attempt to close the atmospheric water balance. In addition to studying the temporal (from a month to several years) and spatial (from 100 km to basin-wide) variabilities of the various terms in the hydrological balance over the global oceans, we will focus on a few regional studies in the tropical Pacific. The relative roles of surface evaporation and surface moisture convergence in changing organized convection and precipitation over the tropical Pacific will be examined.

W92-70154 **148-90-38**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
GREENHOUSE LONG TERM DATA BASE
M. T. Chahine 818-354-6057
(578-12-20)

The overall purposes of this proposed investigation are to: (1) accelerate by a factor of two (over the current plans) the development of a long term data set from the HIRS2/MSU satellite observations; (2) apply this information to investigate changes in atmospheric moisture content and regional cloud distribution due to the greenhouse effect; and (3) provide a framework in which to define those climate variables which are most sensitive to the effects of increased greenhouse gases. The results will yield vital data for studies of climate change. The data set will be derived in collaboration with Dr. Joel Susskind (Goddard Space Flight Center). Jointly, we will analyze two years of High Resolution Infrared Sounder/Microwave Sounding Unit (HIRS/MSU) observations in each year of the proposed investigation. The results will be applied to study the effects of increased greenhouse warming on changes in tropospheric moisture (T. Barnett) and on latitudinal shifts in regional patterns of cloud distribution (M. Chahine and R. Haskins). The proposed approach is based on model simulations which point to a strong signal in the atmospheric moisture field as a result of increased greenhouse gases. Furthermore, model simulations indicate a greenhouse signal also in increased cloudiness and precipitation in the high latitude regions of the Northern Hemisphere, due to increased penetration of moisture-rich warm air. The results of this effort will provide simultaneous determination of several critical atmospheric and surface parameters required for studying earth as an integrated system. This effort also satisfies two of the three objectives of the NASA interdisciplinary research program.

Planetary Geology/Geophysics

W92-70155 **151-01-60**
Ames Research Center, Moffett Field, CA.
SOLAR SYSTEM STUDIES
P. Cassen 415-604-5597

The objective of this RTOP is to contribute to the understanding of the origin and evolution of the Solar System, one of NASA's most basic goals. Research is focused on modeling the processes that led to the formation of the planets and other solar system bodies. The results obtained are of both immediate and long-term value to NASA in guiding the planning of future missions to primitive bodies, outer planets, and Mars. The approach of the RTOP is to use theoretical concepts, physical insight and mathematical modeling together with astronomical and geological data, and experiments relating to aeolian processes, to construct self-consistent mathematical models of planetary processes and structures. Problem areas that are being addressed include: the dynamics and evolution of the solar nebula and protostellar disks in general; the nature of primitive bodies such as comet nuclei; the formation of planets and satellites; the structure and origin of planetary rings; and the interaction of planetary atmospheres with surfaces.

W92-70156 **151-01-70**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
PLANETOLOGY
C. F. Yoder 818-354-2444

This RTOP is a collection of individual planetary geology and geophysics tasks to improve the understanding of: (1) physical processes and compositions on planetary surfaces; (2) solar system formation and dynamics; and (3) the interaction between solid body dynamics and planetary surface features and processes. The scope of studies under this RTOP addresses planets, satellites, the moon, asteroids, comets, and the solar system itself. A variety of disciplines are included in this collection of tasks, ranging from theoretical studies to photogeology, comparative planetology, and data analysis. Many of the geologically oriented tasks feature supplementary studies of analog geologic processes that occur on the earth. Other observationally oriented tasks include laboratory studies of materials that occur on planetary surfaces. The primary objective of this research is an increased understanding of geologic and geophysical processes in the solar system, with emphasis on both the present characteristics of planetary bodies and their origin and geologic history. These studies include the scientific interpretation of data from past missions and provide support for the planning and instrumentation of future missions. This RTOP supports various computational, experimental, and image processing facilities and capabilities at the Jet Propulsion Laboratory (JPL), including the NASA Regional Planetary Image Facility.

W92-70157 **151-02-50**
Goddard Space Flight Center, Greenbelt, MD.
PLANETARY GEOPHYSICS AND TECTONICS
Maria T. Zuber 301-286-2129

The objective of the proposed work is to gain insight into the mechanical structures and stress histories of the lithospheres of the terrestrial planets, with emphasis on Mars and Venus. Our approach will be to: (1) develop numerical (finite element) models of compressional ridge formation to address the nature of ridge belts on Venus and wrinkle ridges on Mars; and (2) investigate the relationship between the state of stress of volcanic edifices and magma chamber mechanics through the development of analytical and numerical models of caldera formation.

Planetary Materials/Geochemistry

W92-70158 **152-11-40**
Lyndon B. Johnson Space Center, Houston, TX.
PLANETARY MATERIALS: MINERALOGY AND PETROLOGY
Gordon A. McKay 713-483-5041

The general objective is to obtain information about the nature, origin, and evolution of the Solar System. The specific objective is to learn the pressure, temperature, and chemical composition of distinct mineralogic phases at the time of their formation. Textures, structures, and chemical composition of minerals found in samples of the Moon, meteorites (asteroids, comets, Mars), cosmic dust (comets, asteroids), and the Earth will be measured

using optical and electron microscope and electron microprobe techniques. Comparison of these results with those from laboratory calibration experiments and theoretical models will lead to pressure, temperature, and history information for parts of Solar System objects.

W92-70159 **152-12-40**
Lyndon B. Johnson Space Center, Houston, TX.
PLANETARY MATERIALS: EXPERIMENTAL PETROLOGY
Gordon A. McKay 713-483-5041

The general objective is to obtain information about the nature, origin, and evolution of the Solar System. The specific objective is to execute laboratory experiments and develop theoretical models which aid our understanding of the crystallization behavior of rock-forming minerals. Mineral systems similar to those found in samples from the Moon, meteorites (asteroids, comets, Mars), cosmic dust (comets, asteroids), and the Earth will be studied experimentally by observing the products of crystallization from experimental charges of known composition cooled under known pressure and temperature conditions. Comparison of these results with the mineralogy of naturally-occurring samples will lead to pressure-temperature and history information for parts of these Solar System objects.

W92-70160 **152-12-40**
Goddard Space Flight Center, Greenbelt, MD.
A LABORATORY INVESTIGATION OF THE FORMATION, PROPERTIES AND EVOLUTION OF PRESOLAR GRAINS
J. Nuth 301-286-9467
(188-44-57)

The objectives of this program are to: (1) determine the mechanism by which refractory materials condense from the vapor and the relative importance of the factors which control the rate of cluster formation and growth for astrophysically relevant species; (2) determine the structure and composition of solids condensed from cosmically abundant refractory mixtures; and (3) monitor changes which occur as the result of thermal annealing, hydration, and exposure to cosmic rays. The result will be the characterization of the grains present in the primitive solar nebula prior to its collapse. Objective 1 will be investigated using a cluster beam apparatus. The equilibrium composition and size distribution of clusters as a function of temperature will be monitored via quadrupole mass spectrometer. Objectives 2 and 3 require a separate flow system designed to produce grains rather than clusters and able to produce large amounts of multicomponent smoke. The structure and composition of the initial grains will be determined; infrared and UV/visible spectra of the smokes will be obtained and the particle morphology will be studied via Scanning Electron Microscope (SEM) and Scanning Transmission Electron Microscope (STEM). Samples will be annealed for various times either in vacuo or in liquid/gaseous water and the induced changes studied by the above techniques. Accomplishment of objectives 2 and 3 also require the use of a low T cryostat and 1 MeV proton source to study the interaction of metal/organic ice mantles formed in the interstellar medium with cosmic radiation, and the consequences of such interactions for grains incorporated into the solar nebula. These consequences may include trapping volatile species in silicates and oxygen isotopic fractionation.

W92-70161 **152-13-40**
Lyndon B. Johnson Space Center, Houston, TX.
PLANETARY MATERIALS: CHEMISTRY
Gordon A. McKay 713-483-5041

The general objective is to obtain information about the nature, origin, and evolution of the Solar System. The specific objective is to measure the concentration of selected chemical elements (major, minor, and trace) in rock samples of interest. Data obtained supplement, and are often combined with, petrologic studies to yield bounds on thermodynamic parameters at the time of rock origin. Rock samples from the Moon, meteorites (asteroids, comets), cosmic dust (comets, asteroids, Mars) and the Earth will be analyzed using a variety of sophisticated techniques, including neutron activation analysis (NAA) x-ray fluorescence, atomic absorption spectrophotometry, gamma-ray spectrometry, and proton-induced x-ray emission. Relative abundances of trace elements in different samples places bounds on the characteristics of the sources from which the rock-forming materials are derived.

W92-70162 **152-13-60**
Ames Research Center, Moffett Field, CA.
PLANETARY MATERIALS - CARBONACEOUS METEORITES AND COMETARY ICE ANALOGS
S. Chang 415-604-5733

The objective of this research is to understand the processes involved in the origin and early evolution of solid bodies in the solar system through the study of meteorites and laboratory analogs of cometary ices. The approach taken to meet this objective focuses on the chemical and mineralogical-petrographic analyses of meteorites and laboratory study of astrophysical ices. The abundance, isotopic composition, and distribution of selected elements are measured; and the occurrence and distribution of various mineral phases are determined in meteorites. Systematic searches for elemental, isotopic, and mineralogic-petrologic correlations between meteorites and within a meteorite will be made so as to elucidate physical-chemical relationships in the meteorite population. From these relationships will be deduced the nature of the processes that were involved in the origins, accretion, and distribution of these objects and their components in the early solar system. In turn, these processes are modeled by laboratory or computer experiments from which the chemical and mineralogical outcomes can be determined. Findings from meteorite analyses and model studies are then compared for self-consistency. The structure, morphology, and composition of cometary ice analogs are determined in laboratory studies conducted under simulated astrophysical conditions. Correlations between laboratory observations and astronomical observations of interstellar and cometary ices will be sought in order to understand the nature and origins of the natural materials.

W92-70163 **152-14-40**
Lyndon B. Johnson Space Center, Houston, TX.
PLANETARY MATERIALS: GEOCHRONOLOGY
Gordon A. McKay 713-483-5041

The general objective is to obtain information about the nature, origin, and evolution of the Solar System. The specific objective is to determine the absolute time when a particular event, such as the eruption of a volcano or the formation of a large impact crater, occurred. The concentrations of radioactive decay products and the corresponding parent isotopes will be measured in carefully selected rock samples using mass spectrometric techniques. With knowledge of the decay constant (half life) for the radioactive element, and assuming a closed chemical system, the time since system closure may be deduced. Systems currently in use are: K-Ar, Rb-Sr, Sm-Nd, Lu, Hf, and U-Th-Pb. Study of extinct radioactive nuclides, such as Pu, leads to information on the interval of time between the formation of the nuclide and its incorporation into a solid.

W92-70164 **152-15-40**
Lyndon B. Johnson Space Center, Houston, TX.
PLANETARY MATERIALS: ISOTOPE STUDIES
Gordon A. McKay 713-483-5041

The general objective is the obtain information about the nature, origin, and evolution of the Solar System. The specific objective is to determine the isotopic composition of selected elements in planetary materials. Isotopically distinct material, which cannot be understood as the product of known fractionation processes, may indicate the presence of pre-solar material. Light elements are studied to learn more about fractionation processes. A secondary objective is to develop an ion microprobe which will provide easier analysis and increased spatial resolution and sensitivity for isotopic composition measurements. Samples of moon rocks and meteorites will be analyzed using mass spectrometric techniques to learn isotopic compositions, mainly of noble gases, hydrogen, carbon, oxygen, and nitrogen. Theoretical calculations will be made to relate the expected products of

nucleosynthesis to observations of anomalous material in meteorites. A commercially purchased ion microprobe is being upgraded in the laboratory of G. J. Wasserburg, CIT.

W92-70165 **152-17-40**
Lyndon B. Johnson Space Center, Houston, TX.
PLANETARY MATERIALS: SURFACE AND EXPOSURE STUDIES
Gordon A. McKay 713-483-5041

The general objective is to obtain information about the nature, origin, and evolution of the Solar System. The specific objective is to learn about the interaction between the space environment, which consists of meteorites, galactic cosmic rays, and solar particle and electromagnetic radiations. Samples of the lunar regolith offer the opportunity to find variations in the intensity of the environmental factors over geologic time. A variety of approaches will be used. The radioactivity of cosmic-ray produced nuclides will be analyzed as a function of sample depth. Surfaces will be studied using electron microscopes. Etchable heavy element ionization damage tracks will be revealed and studied. Solar wind noble gases will be analyzed mass spectrometrically. Multidisciplinary studies will be performed using selected samples.

W92-70166 **152-17-70**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
A NEW LOOK AT THE APOLLO GAMMA-RAY DATA
C. F. Yoder 818-354-2444

The purpose of this RTOP is to review and refine Apollo gamma-ray data sets and recover additional element abundances (aluminum and uranium) for the moon using the existing Apollo 15 and 16 gamma-ray spectrometer observations. The end product shall be improved maps of the surface abundance of several elements covering 22 percent of the moon mapped by this instrument. In the coming year, we plan to: (1) submit for publication an article discussing the applications of the gamma ray data to lunar science and another featuring a full set of K concentrations covering the Apollo 15 and 16 ground tracks; (2) select the best element data sets from the 14 published and 2 unpublished full and partial sets currently available; (3) begin the energy band analysis of Al; (4) automate the iterative procedure whereby an observed data field is deconvolved to a predicted surface distribution; (5) evaluate the extent to which a simpler form of spatial deconvolution may be applied to all separated elements; and (6) compare Apollo gamma-ray and Galileo imaging spectrometer observations of the moon within regions of overlap.

W92-70167 **152-20-01**
Goddard Space Flight Center, Greenbelt, MD.
MICROGRAVITY NUCLEATION AND PARTICLE COAGULATION EXPERIMENTS
J. Nuth 301-286-9467
(152-12-40; 188-44-57)

Laboratory studies of the vapor-solid nucleation of refractory species have been hampered due to thermal convection. This problem is especially severe for refractory species such as SiO, C, Al2O3, and SiC which are important in both astrophysics and meteoritics. Well controlled studies of particle coagulation are difficult to perform on earth since larger particles tend to settle out just as the experiments produce aggregates of macroscopic size. We will construct and test a system which will yield high quality data on the nucleation of refractory materials and also produce a cloud of well characterized particles which would be used to carry out studies of particle coagulation on a number of refractory species aboard NASA's KC-135 research aircraft. We will also characterize the magnetic properties of the Fe-Ni system and the magnetic record contained in meteoritic materials. Refractory vapor will flow from a heated crucible, down a controlled temperature gradient until nucleation is detected via light scattering from the newly formed grains. Particles will be collected in flight and characterized on the ground. Particle size, composition, crystal structure, and morphology will be determined. If the particles produced during the nucleation experiment are uniform, then the end of a nucleation experiment will constitute the beginning of a particle coagulation experiment. Changes in the particle size distribution due to aggregation will be monitored via light scattering and extinction measurements. Because of the short time available in 0 gravity (t less than 25 s) we expect that only nucleation experiments will be possible on the KC-135. Coagulation experiments will await the more extended timescales available during Space Shuttle flights. Magnetic characterization of materials will occur both on the ground and aboard the KC-135 Aircraft.

W92-70168 **152-20-40**
Lyndon B. Johnson Space Center, Houston, TX.
PLANETARY MATERIALS: COLLECTION, PRESERVATION AND DISTRIBUTION
Gordon A. McKay 713-483-5041

The objective of this RTOP is to provide for: (1) maintenance of the Lunar Sample Collection under secure, controlled environment conditions; (2) the description of samples as new materials are prepared for analysis; (3) the maintenance records of the status and distribution of lunar samples; (4) the supply of lunar samples to approved investigators and for display purposes; (5) technical monitoring of NASA-funded grants/contracts to planetary materials investigators; (6) similar functions for the Antarctic meteorite collection, including initial description, processing for distribution to investigators, and maintenance under controlled environment; (7) dissemination of information on meteorite collection ; (8) staff members participation in field collection; (9) the collection of cosmic dust samples using high altitude aircraft; (10) the characterization of dust particles; (11) distribution to scientific investigators; (12) dissemination of information; and (13) development of curatorial techniques for, and the educational use of, materials from the various collections. The operation, which is undertaken by support contractor personnel, is directed by civil servant scientists and administrators. The program provides samples and information for about 65 domestic and foreign lunar sample investigator groups, over 100 meteorite investigator groups, and ten cosmic dust investigator groups.

W92-70169 **152-30-40**
Lyndon B. Johnson Space Center, Houston, TX.
PLANETARY MATERIALS: GENERAL OPERATIONS AND LABORATORY FACILITIES
Gordon A. McKay 713-483-5041

General operations support a variety of institutional and scientific support tasks at JSC that are considered essential for the conduct of research and for implementation of the Planetary Materials and Geochemistry Program (PMGP). Inhouse support provides for co-sponsorship of conference, laboratory costs required by visiting scientists using existing facilities, and for cost required to operate common laboratory and computer facilities. This plan also provides inhouse laboratory maintenance for the visiting scientist programs of NASA (National Research Council, Lunar and Planetary Institute, NASA Graduate Intern, etc.). A significant element of this RTOP is an annually updated plan for the systematic modernization of laboratory equipment and instruments. The overall plan includes funding from other benefiting NASA and other agency programs. The PMGP is asked to support about 20 percent of the modernization.

Planetary Atmospheres R&A

W92-70170 **154-01-80**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
PLANETARY ATMOSPHERES PROGRAM
J. F. Appleby 818-354-3943

This group of 26 interrelated research tasks addresses the chemical, physical, and dynamical properties of the atmospheres

of planets, satellites, and comets. These investigations examine the atmospheric and ionospheric aspects of planetary objects (other than Earth), including studies of atmospheric chemistry; comparative planetology; atmospheric evolution; radiation balance, thermal structure, molecular composition, radiative-dynamical coupling, and spatial and temporal variations; clouds, dust, aerosols, and the horizontal and vertical distributions of these materials; climate and climate history; atmospheric wave and wind fields, mass transport, and wave-mean flow interactions; and the composition and dynamics of cometary comae and related dust phenomena. The basic objective of this research is to determine, from observational data, laboratory experiments, and theoretical considerations, the present characteristics and evolution of planetary atmospheres. A major objective is to carry out interpretive analysis of observational results obtained by unmanned spacecraft missions and ground-based telescopic observations of the gaseous envelopes of planetary objects throughout the solar system and to derive new missions and new observations to further our knowledge of the solar system. This RTOP also supports IR spectroscopic and high-energy laboratory measurements for planetary atmospheres research, and services of a detailee to the Planetary Atmospheres Program Office at NASA Headquarters.

W92-70171 **154-10-80**
Ames Research Center, Moffett Field, CA.
PLANETARY ATMOSPHERIC COMPOSITION, STRUCTURE, AND HISTORY
J. B. Pollack 415-604-5530
(196-80-00)

The objective of this RTOP is to determine the properties and physical processes characteristic of planetary atmospheres by means of theoretical modeling and spacecraft and ground-based data interpretation. These properties include their temperature structure, aerosols, cloud layers, gaseous constituents, and opacity sources. The approach of this RTOP is as follows. Emphasis is placed on reducing and analyzing data returned from spacecraft missions, such as Voyager, or preparing for data expected from future spacecraft missions, such as Galileo. However, use is also made of relevant ground-based observations. In addition, the origin and evolution of planetary atmospheres and the outer planets are studied by constructing models that are constrained by relevant spacecraft and ground-based data.

W92-70172 **154-20-80**
Ames Research Center, Moffett Field, CA.
DYNAMICS OF PLANETARY ATMOSPHERES
R. E. Young 415-604-5521

The objectives of this RTOP are to model the atmospheres of Venus and Mars and to compare model results with spacecraft data and attempt to understand the dynamical effects of varying planetary rotation rate, solar energy deposition, infrared opacity, atmospheric mass and composition. The approach of this RTOP is to study the dynamics of the atmospheres of Venus and Mars using multi-dimensional circulation models. The coupled momentum and energy equations are solved numerically using combinations of finite difference and spectral methods.

W92-70173 **154-50-80**
Goddard Space Flight Center, Greenbelt, MD.
ATOMIC AND MOLECULAR PROPERTIES OF PLANETRY ATMOSPHERIC CONSTITUENTS
Dennis C. Reuter 301-286-2042
(196-41-54; 147-12-20; 188-44-57)

The principal goal of this laboratory spectroscopy program is to measure the spectral line parameters of planetary and cometary constituents. In the case of lower resolution planetary observations, such as Voyager IRIS (4/cm), identifications and abundance determinations require laboratory spectra of similar resolution which can be directly compared with the observations. Condensed phases of some molecular constituents may also contribute to the Voyager spectra. The highest possible spectral resolution is required when single features apparent in medium or high resolution Fourier transform (FTS) spectra are composed of more than one molecular transition, and the parameters (1) frequency, (2) strength, (3) lower state energy, and (4) foreign-broadening must be known for each as input in modeling the atmosphere. For high resolution FTS and heterodyne observations the need for ultra-high resolution laboratory data is especially critical, since the bandwidths accessible to these receivers are narrow and Doppler line profiles are completely resolved in the observed spectra. A combination of tunable diode laser (TDL) and FTS laboratory spectra can supply a complete set of line and band parameters anywhere in the infrared. In this program TDL and FTS spectrometers will be applied to selected vibration-rotation bands of planetary molecular species.

W92-70174 **154-60-80**
Goddard Space Flight Center, Greenbelt, MD.
PLANETARY AERONOMY: THEORY AND ANALYSIS
R. E. Hartle 301-286-8234

The basic objective is to study the observed properties of the neutral atmospheres and ionospheres of the planets and their satellites in order to identify and interpret the physical and chemical processes governing their behavior, including solar planetary relationships. One of the motivating philosophies is that the study of processes occurring in the atmospheres and ionospheres of the planets and their satellites provides important insights into the nature of similar processes operative at other planets and satellites (including Earth) but under different parametric conditions and vice versa. The investigations are pursued by analyzing and interpreting experimental data derived largely from flight programs after funding from project offices has terminated. The data is used to determine the various chemical, compositional, dynamical and energetic states of the respective atmospheres and ionospheres, including the transport and deposition of mass, momentum and energy in these regimes. In general, the approach involves the development of empirical descriptions of either global or small scale phenomena using data sets from a variety of spacecraft. These empirical descriptions of the atmospheres and ionospheres are subsequently interpreted using theoretical models developed to deduce the physical and chemical processes involved. Some of the specific phenomena addressed in this investigation include: atmospheric and ionospheric motions on Venus, Jupiter and Earth, interactions of solar wind and/or magnetosphere with atmospheres of Venus, Titan, moons of Uranus and Earth, including modification of transport coefficients by instability processes, solar planetary relationships, comparative planetary atmospheres, etc.

W92-70175 **154-60-80**
Ames Research Center, Moffett Field, CA.
STUDIES OF CLOUD PROCESSES ON THE OUTER PLANETS
C. R. Stoker 415-604-6490
(154-30-80)

The objective of this RTOP is to understand cloud processes on the outer planets including the vertical structure of clouds and aerosols in these atmospheres and the physical and dynamical processes responsible for discrete cloud formation. Theoretical studies and analysis of spacecraft data are performed to determine the vertical structure of clouds and how these structures are produced. The effects of cloud microphysical processes on bulk cloud structure in the atmospheres of the outer planets Jupiter, Saturn, Uranus, and Neptune; the manner in which cloud precipitation formation and mass loading of updrafts by condensates affects the dynamics of convective clouds; the life cycles of convective clouds; and the conditions required to initiate moist convection on the outer planets are being investigated. The approach of this RTOP is to use theoretical modeling and analysis of spacecraft data to study the vertical structure of clouds in the atmospheres of the outer planets and theoretical modeling to help understand how this structure is produced. We are developing numerical models of moist convective clouds and incorporating procedures to study the formation and growth of condensate clouds in the atmospheres of the outer planets. We are fitting data derived from Voyager images to radiative transfer models to help understand the vertical structure of discrete clouds on the outer planets.

W92-70176 **154-90-80**
Ames Research Center, Moffett Field, CA.
PLANETARY LIGHTNING AND ANALYSIS OF VOYAGER OBSERVATIONS
W. J. Borucki 415-604-6492

The objectives of this RTOP are to determine the role of atmospheric electrical processes in the evaluation of planetary atmospheres and to delineate the electrical and meteorological processes that give rise to the extreme electric fields required for lightning. The approach of this RTOP is to use comparative planetology; i.e., to compare the spacecraft observations with terrestrial observations and theory in order to understand the processes occurring on other planets and to check the applicability of the theories that have been developed to explain terrestrial lightning and atmospheric electricity. An analysis of Voyager spacecraft images shows that Jovian lightning characteristics are dissimilar to those of terrestrial lightning. Further efforts to characterize lightning activity and characteristics on other planets are under way. A theoretical model of the lightning discharge column is being constructed to identify the physical processes that produce specific molecular products. Laboratory work is being conducted to determine the yield of various molecules produced by lightning discharges.

W92-70177 **154-95-80**
Ames Research Center, Moffett Field, CA.
MARS 3-D GLOBAL CIRCULATION MODEL
R. M. Haberle 415-604-5491

The objective of this RTOP is to further the understanding of the processes controlling seasonal cycles of dust, water, and carbon dioxide that characterize the climate of Mars. While the Mariner 9 and Viking spacecraft missions have provided a good first order definition of the amplitude and phase of these cycles, the processes controlling them remain uncertain. The approach of this RTOP is to numerically simulate various aspects of these cycles using one, two, and three-dimensional climate models. The one-dimensional model is a time-marching boundary layer type model that includes the solar and infrared radiative effects of dust as well as carbon dioxide. It is used to isolate the effects of dust on temperature structure and feedback mechanisms between dust loading and dust raising. The two-dimensional model is a zonally symmetric primitive-equation model with a tracer transport capability. It is used to study the role of atmospheric transport on the water cycle, and the radiative-dynamical feedback effects of dust on the general circulation. The three-dimensional model is used to study the effects of large-scale eddy motions on the transport of water.

Mars Data Analysis

W92-70178 **155-04-00**
Ames Research Center, Moffett Field, CA.
MARS SURFACE AND ATMOSPHERE STUDIES
R. M. Haberle 415-604-5491

The objective of this research is to better understand (1) the nature and variability of the Martian planetary boundary layer, (2) the ability of water molecules on Mars to adsorb onto soil particles in the presence of a carbon dioxide background gas, and (3) the radiative properties of suspended dust particles in the Martian atmosphere. This research is stimulated by NASA's ongoing planetary exploration program, and the President's recent Space Exploration Initiative. The approach of this effort involves observational, theoretical, and experimental analyses. The observational approach involves further reduction of Viking and Mariner 9 data. The theoretical approach involves use of high speed computer codes to solve complex radiative transfer and fluid dynamical problems. The experimental approach will create a near Mars-like environment to develop new insight into otherwise intractable problems. Each of these approaches makes effective use of the computational and laboratory facilities at Ames.

W92-70179 **155-04-00**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
MARS DATA ANALYSIS/PLANETARY ATMOSPHERES
T. E. Thorpe 818-354-3611

This RTOP relates to the implementation of the science investigations of the Gamma Ray Spectrometer and Thermal Emission Spectrometer. FY-91 activities include construction of calibration databases to allow interpretation of flight telemetry for the measurements of the elemental and mineralogical content of the Martian surface and pressure profiles of the atmosphere.

W92-70180 **155-20-00**
Goddard Space Flight Center, Greenbelt, MD.
MARS DATA ANALYSIS
Jacob I. Trombka 301-286-5941

A number of cooperative programs of Mars Exploration and Data Analysis were undertaken as part of the joint U.S./U.S.S.R. Solar System Exploration Working Group. These programs include an Antarctic balloon flight for calibration of detectors used on both U.S. and Soviet Missions and U.S. Co-Investigator support for the Soviet Mars '94 Mission.

W92-70181 **155-20-00**
Ames Research Center, Moffett Field, CA.
PLANETARY DATA SYSTEM
R. M. Haberle 415-604-5491

The objective of this research is to (1) provide modeling data to planners of the Mars 94 mission to help determine site selection for the landed packages, (2) provide modeling data to the Planetary Atmospheres Node of the Planetary Data System (PDS), and (3) provide a stable center of expertise in the archiving, analysis, and interpretation of planetary ring data obtained from ground-based and spacecraft observations. This research is stimulated by NASA's ongoing planetary exploration program and the need to provide easy access to the data sets that come from it. The approach of this effort involves the use of a general circulation model of the Martian atmosphere to simulate various circulation patterns at different locations, times of year, and dust loadings. The model results can then be used to forecast wind and temperature conditions at candidate landing sites to assess the mobility of the balloon component of the landed packages aboard the Mars 94 spacecraft. The same model will be used to provide simulated data to the planetary atmospheres node of the PDS. An additional approach is to acquire, format, and catalog all relevant planetary ring data into a database management system that will provide user friendly access for the planetary community. Each of these approaches makes effective use of the computational and laboratory facilities at Ames.

W92-70182 **155-20-01**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
PLANETARY DATA SYSTEM
S. K. McMahon 818-354-8127
(656-61-06)

The general PDS goal is to provide the planetary community with the access to high quality archive data products beyond the life of any one flight project. Specific objectives include: (1) publish quality, well-engineered data sets; (2) leverage with flight projects for PDS-compatible data sets; (3) provide expert scientific help to the planetary science community in use of the archived data; and (4) be responsible for archive data standards. PDS is a geographically distributed system with eight major components or nodes: central node at JPL, the NAIF engineering node, and six science discipline nodes led by major universities. The system now supports operations for active science users as well as planning for the future system evolution. In addition, there are significant resources spent: (1) restoring specific data sets needed by the science community, and (2) working with active flight projects to ensure they prepare their archive data products in a useful,

PDS-compatible approach so that users gain quick access to them and PDS will not need to restore them in later years.

W92-70183 **155-20-02**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
MARS 94 CARTOGRAPHY - PARTICIPATING SCIENTIST
T. C. Duxbury 818-354-4301

The objectives of this RTOP are to solve problems related to the total science objectives of the Mars 94 mission using TV imaging observations gathered from the Orbiters, small stations, penetrators and balloons, and from Orbiter radio occultation and altimetry observations. Also, this proposal would benefit the U.S. Strategic Exploration Initiative (SEI) Robotics missions. To help give focus to this proposal, this investigation would work closely with and through the U.S./U.S.S.R. Joint Working Group for Solar System Exploration and its Implementation Teams for Annexes nos. 2, 3, 4 and 15 and with the U.S. Mars Science Working Group supporting the SEI Robotics missions. The objectives for Mapping are organized into six categories: (1) Geodesy and Cartography; (2) Atmospheric Winds and Circulation; (3) Surface Photometry and Thermal Inertia; (4) Correlative and Interdisciplinary Studies; (5) Phobos and Deimos; and (6) Searches. The objectives within each of these categories share common analysis and approaches and utilize observations from the same sets of instruments. An approach to this effort would rely heavily on existing capabilities that this proposer was developed and used successfully on previous space missions including Mariner 9, Viking, Voyager and the Soviet Phobos Mission and in supporting the U.S./U.S.S.R. Joint Working Group. The experience gained from these missions would be used to support the definition, instrument development and ground testing, ground data system development, instrument flight testing, science planning, mission operations, correlative data set generations, data analysis, data management, and publications of results phases of the mission. The following sub-sections describe the objectives and approaches of this proposal.

W92-70184 **155-20-03**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
MARS 94 GRAVITY
W. L. Sjogren 818-354-4868

Long Range - Starts 1995: (1) Refine the gravity field of Mars; (2) Construct and test interior structure models of Mars using the gravity data; (3) Determine Mars spin pole orientation and separate the moments of inertia with a precession rate determination; (4) Determine new masses of Phobos and Deimos. Short Range - now thru 1994: (1) Coordinate with the Soviets on their mission design and hardware capabilities; (2) Understand their efforts in this field; (3) Suggest to Soviet and U.S.A. managers ways to optimize and make this experiment better within its existing bounds. Long Range: Analyze simultaneous Doppler Radio Tracking of our Mars Observer Spacecraft and the Soviet's two Mars 94 spacecraft, as well as surface eggs and balloon. Invert these data for gravity parameters. Short Range: Read literature from Soviets; Write letters to Dr. Akim in U.S.S.R.; Go to meetings where the mission will be discussed; Discuss Mars 94 when Dr. Akim visits JPL for MGN.

W92-70185 **155-20-04**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
MARS 94 WINDS
R. A. Preston 818-354-4631

The Mars '94 balloons will be used to measure the winds in the lower atmosphere of Mars. Down-looking cameras onboard the balloon gondolas will likely be the principal instruments used in the wind measurements. Registration of pairs of overlapping images provides information on the horizontal motion of the balloons, and hence, the winds. However, measurements from other instruments are necessary to optimize the image registration process and to interpret the image pair offsets. In addition, the dynamics of the balloon-gondola system must be well understood and Doppler measurements on radio links from the balloons to the orbiters and the Earth may be important to the optimum wind determination scheme.

Planetary Instrument Definition

W92-70186 **157-03-50**
Goddard Space Flight Center, Greenbelt, MD.
PLANETARY INSTRUMENT DEFINITION AND DEVELOPMENT
Jacob I. Trombka 301-286-5941

The objective of the investigation is to develop remote-sensing and in-situ measurement systems for geochemical and geophysical exploration of the planets, asteroids, and comets. These studies will be consistent with planetary exploration programs being developed in the Solar Systems Exploration Program of the NASA. Specifically these tasks include instrument development in the fields of x-ray, gamma-ray, neutron, and mass spectroscopy. Both theoretical and experimental studies will be used in these investigative studies. Further studies will include investigation of the affects of the radiation environment in the operation of these detector systems. Prototype detector systems will be constructed and tested in the laboratory environment. Balloon Flights and measurements in environmental chambers will be used to test for space operation. The data obtained can then be used in the determination of detector sensitivity, calibration, and design for planetary space flight missions.

W92-70187 **157-03-70**
Goddard Space Flight Center, Greenbelt, MD.
IMAGING SPECTROPOLARIMETER
John J. Hillman 301-286-7974

The goal of this investigation is to verify the conceptual design for a novel, versatile imaging spectropolarimeter experiment. Novel aspects of the design include the use of Acousto-Optical Tunable Filters (AOTFs) to provide spectral discrimination and polarization, and new-technology array detectors to provide spectral imaging in the Short-Wave Infrared (SWIR; 0.8 microns less than lambda less than 3 microns). A PIDDP (Planetary Instrument Definition and Development Program) project conducted at JPL in FY-89 and FY-90 generated quantitative data on AOTF performance and optimal design approaches for such an experiment. Experience gained from that project led to the preparation of the POLARIS proposal for the Cassini Orbiter. The objective is to draw upon the same base of experience and data to construct a proof-of-concept version of such an experiment and to demonstrate its capabilities by using it to make practical observations in the field. Potential platforms for field observations include aircraft and/or stationary booms. Potential applications of this design concept include compact multispectral cameras for Discovery-class planetary missions and imaging spectropolarimeters for terrestrial remote-sensing.

W92-70188 **157-03-70**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
INTERFEROMETER-BASED IMAGING SYSTEM (IBIS) FOR DETECTION OF EXTRASOLAR PLANETS AND FAINT SUBSTELLAR COMPANIONS
D. J. Diner 818-354-6319

The objective is the demonstration by analysis and laboratory experiment of the key elements of an observing system that would enable a space or lunar-based infrared imaging telescope of 10 to 20 m to conduct a statistically meaningful search for Jupiter-like planets to 25 parsecs and detect Earth-like planets within a smaller search space. There are three key technology components of this concept: a coronagraph to suppress the star and apodize its diffraction pattern, a rotational-shearing interferometer to provide further starlight suppression and sense wavefront errors at mid-spatial frequencies, and a deformable mirror to adaptively compensate for these errors and eliminate scattered light in the planetary-search region of the focal plane. Since the deployment of a very-large aperture is decades away, the approach is to develop the technologies for a scaled-down system maintaining the same angular resolution but operating the shorter IR wavelengths. Such an instrument would be scientifically useful for the detection and study of brown dwarfs and would demonstrate

much of the technology required for planet detection with the larger aperture. The approach for the immediate study is: (1) to model the effectiveness of the coronagraph, rotational-shearing interferometer, and deformable mirror in suppressing starlight, (2) to demonstrate in the laboratory a high level of starlight suppression with a rotational-shearing interferometer, and (3) to refine the calculations of the projected performance of a prototype system.

W92-70189 **157-04-80**
Ames Research Center, Moffett Field, CA.
PLANETARY INSTRUMENT DEFINITION AND DEVELOPMENT PROGRAM - MARS SOIL ANALYSIS
G. C. Carle 415-604-5765
(199-52-52; 107-20-08; 157-05-50)

The objective of this research is to develop flight instrument capability and hardware prototypes for the comprehensive analysis of the atmosphere and surface material of Mars. The approach of the RTOP is to develop a highly efficient dust collector for use on the surface of Mars. Aeolian materials gathered with this collector will be analyzed with a Gas Chromatograph-Ion Mobility Spectrometer so their chemical composition may be determined.

W92-70190 **157-05-50**
Goddard Space Flight Center, Greenbelt, MD.
PLANETARY INSTRUMENT DEVELOPMENT PROGRAM/PLANETARY ASTRONOMY HIGH TEMPERATURE SUPERCONDUCTOR BOLOMETERS
J. Brasunas 301-286-3488

This RTOP supports the development of components for advanced generation infrared spectrometers for planetary observations. Task 06 will develop higher sensitivity far-infrared detectors campatible with passive radiative coolers on long-term missions (greater than 5 years). Specifically, this task will develop high-temperature superconductor (HTS) bolometers for outer planet missions such as the 1996 Cassini mission to Saturn and Titan, for future planetary missions such as Uranus Orbiter, Neptune Orbiter, lunar and Mars missions, long-term earth orbiting missions such as EOS and the Orbiting Planetary telescope, and small/inexpensive missions such as the Small Explorer series.

W92-70191 **157-20-40**
Lyndon B. Johnson Space Center, Houston, TX.
PLANETARY INSTRUMENT DEFINITION AND DEVELOPMENT
Gordon A. McKay 713-483-5041

The objectives are twofold: (1) to define and develop spacecraft-based instrument technology which shows promise for use in scientific investigation in future planetary missions, and (2) to modernize and enhance laboratories used in research supported under NASA's Planetary Materials and Geochemistry Program, through acquisition of new laboratory equipment and through upgrades to existing equipment. Two candidate instruments for planetary missions will be defined and conceptually designed. One is an integrated calorimetric thermal analyzer and evolved gas analyzer, suitable for deployment to the surface of Mars as part of the Mars Environmental Survey (MESUR) mission. The other is a combined Mossbauer spectrometer and X-ray fluorescence spectrometer, also suitable for the MESUR mission. In addition, funds will be provided for equipment upgrades for both NASA and non-NASA laboratories currently supporting the Planetary Materials and Geochemistry research program, based on research and upgrades proposed in response to the NASA Research Announcement in Planetary Materials and Geochemistry of January 15, 1991. The proposals will be reviewed by the Lunar and Planetary Geosciences Review Panel during June, 1991. Specific upgrades proposed for JSC laboratories include acquisition of a modern rare gas mass spectrometer and a high-temperature scanning differential calorimeter.

Solar Terrestrial SR&T

W92-70192 **170-10-10**
Goddard Space Flight Center, Greenbelt, MD.
COSMIC AND HELIOSPHERIC PHYSICS
J. F. Ormes 301-286-8801

This RTOP is to support efforts within the Space Sciences Directorate at the Goddard Space Flight Center aimed at understanding the acceleration, interactions, and transport of energetic particles in astrophysical plasmas. The approach is remote and in-situ observations of energetic particles of galactic and solar origin in order to understand their propagation in galactic and solar system magnetic fields, and to study the properties of the space plasmas in which their acceleration takes place. The particles observed are the nuclear and electronic species: their energy spectra, their charge states and isotopic composition, and their distribution in space. Planning of new missions is an important component of this research as analysis leads to increased understanding but more sophisticated questions. There is also a large effort directed at processing, analyzing, and interpreting the data involving correlative studies from a variety of spaceflight experiments such as Voyager, Pioneer, International Sun Earth Explorer (ISEE), Interplanetary Monitoring Platform (IMP), and Helios and comparisons with data from other observations, both space and ground based. A strong emphasis is placed on creating the theoretical framework for interpreting the results. This RTOP supports graduate students thesis research, research associates, and occasionally a senior faculty member on leave from an academic institution.

W92-70193 **170-10-10**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
COSMIC AND HELIOSPHERIC PHYSICS
R. Goldstein 818-354-0241

This RTOP consists of 8 subtasks: (1) Solar Gamma-Ray Spectroscopy (170-10-10-67, J. Ling, W. Wheaton): demonstrate critical technology for a solar high resolution gamma ray spectrometer; (2) Magnetohydrodynamics (MHD) Processes in the Solar Wind (170-10-10-86, B. E. Goldstein): theoretical analysis of wave and shock processes in the solar wind; (3) Solar Wind Data Analysis (170-10-10-88, M. Neugebauer): investigations of heliospheric physics, including the acceleration of the solar wind and stream-stream interactions, using solar wind data acquired by past missions; (4) Magnetospheric and Interplanetary Data Analysis (170-10-10-89, E. J. Smith): analysis and interpretation of Pioneer, International Sun Earth Explorer (ISEE) vector helium magnetometer data and ISEE plasma wave data; (5) Radio Analysis of Interplanetary Scintillations (170-10-10-91, R. Woo): probing of solar wind regions inaccessible to spacecraft using the scattering and scintillation of the spacecraft radio signals, (6) Model Analysis of Heliospheric (170-10-10-94, J. Ajello): analysis of solar and interplanetary UV from interplanetary spacecraft (PV, Voyager, Galileo); (7) Particle Simulations of the Solar Wind Termination Shock and Alfven Wave Decay (170-10-10-96, P. Liewer): particle simulation codes are used to study Alfven wave instability in the solar wind, and effect of interstellar pickup ions in the solar wind; and (8) Causes of North-South Bz Variations in Interplanetary Driver Gases (170-10-10-97, B. Tsurutani): examine magnetic structure in high speed streams using ISEE-3 data.

W92-70194 **170-10-10**
Ames Research Center, Moffett Field, CA.
MAGNETOSPHERIC PHYSICS - PARTICLES AND PARTICLE/FIELD INTERACTION
A. Barnes 415-604-5506

The objective of this RTOP is to improve the understanding of the solar wind, its origin, termination, dynamics and turbulence, as well as its interaction with planetary obstacles. The approaches of this RTOP are to conduct theoretical studies aimed at understanding the large-scale dynamics of the solar wind, its acceleration and heating mechanisms, and waves and turbulence

in the solar wind. These studies employ known theoretical techniques of plasma physics and magnetohydrodynamics, and also often require extensions of basic theoretical plasma physics. Theoretical developments will be related to spacecraft plasma and magnetic data, as well as to indirect observations of the solar wind. Theoretical studies of the solar wind-Venus interaction will be conducted.

W92-70195 **170-10-10**
Marshall Space Flight Center, Huntsville, AL.
TECHNIQUES FOR MEASUREMENT OF COSMIC RAY COMPOSITION AND SPECTRA
T. A. Parnell 205-544-7690

An observational program to study cosmic ray composition, spectra, and interactions in the region 10(exp 12) to 10(exp 14) eV is being pursued with balloon-borne emulsion chambers in collaboration with the Japanese-American Cooperative Emulsion Experiments (JACEE) team. Techniques for extending measurements to the 10(exp 14) to 10(exp 16) eV region with future long duration balloon and space flight experiments are being developed. In addition to analysis of data from previous balloon flights, the following studies are in progress at MSFC: (1) apply 3-D hadronic-electromagnetic cascade simulation of x ray film spots and scanning microdensitometry to measure primary energy and produced particle transverse momentum; (2) develop computer assisted techniques for microscope measurement of composition and interaction data in emulsion chambers; (3) develop a technique for the estimation of heavy nucleus energy above 10(exp 14) eV by measurement of linear frequency of Coulomb electron pairs in track emulsions; and (4) investigate the use of emulsion chambers with a superconducting magnet to perform nucleus interaction studies in balloon-borne cosmic ray experiments.

W92-70196 **170-10-10**
Marshall Space Flight Center, Huntsville, AL.
MHD STUDIES IN SPACE PLASMA THEORY: CORONAL AND INTERPLANETARY PHYSICS
S. T. Suess 205-544-7611
(170-38-53)

Analytical, numerical, and empirical models are being developed while studying magnetohydrodynamic waves and the heliospheric termination shock. Studies of Alfven waves focus on Alfven waves, and their propagation, decay, mode coupling, and application for heating the solar corona. For the heliospheric termination shock, its asymmetry is being modeled, predicting this asymmetry at the heliographic latitude of Voyagers 1 and 2, taking into account solar wind mass flux spatial dependences and variations with solar cycle, considering possible dynamic time-dependent effects and adding the effect of momentum exchange with interstellar neutrals to the model. Data resources include Ulysses, HELIOS 1 and 2, the NOAA/SEL (Space Environment Laboratory) hydrogen-alpha magnetic field maps, Voyagers 1 and 2, and Pioneer 10. The Alfven wave research is aimed at preparing for Solar Probe and Coronal Companion.

W92-70197 **170-38-51**
Goddard Space Flight Center, Greenbelt, MD.
DEVELOPMENT OF SOLAR EXPERIMENTS AND HARDWARE
Brian R. Dennis 301-286-7983

The objective of this RTOP is to develop new scientific instruments which will contribute to the solution of well-defined solar research problems, such as: the study of coronal structures that relate to the solar wind and interplanetary plasma; the study of the sources of high energy solar flare particles; and the direct study of the solar interior as revealed by surface oscillations. Most of the proposed development programs have the ultimate goal of providing critical hardware for future payloads on problem oriented space missions. Instruments considered for such payloads include: a stigmatic EUV spectrograph to observe coronal features with high spatial and spectral resolutions; a high resolution imaging system for measuring the spatial, spectral, and temporal characteristics of hard X ray emissions from solar flares; and a device to make high precision measurements of the Sun's diameter and its variations with time. Another task will develop special ground based instrumentation to provide supporting observations necessary to supplement data obtained by solar space missions. Also covered are extended definition studies for future solar instrumentation and evaluation of new optical and detector technologies that may be applicable to future solar EUV and X ray observations, including high speed data acquisition systems, multilayer optical coatings, and X ray detectors with high spectral resolution and with high spatial resolution.

W92-70198 **170-38-51**
Marshall Space Flight Center, Huntsville, AL.
CASES AND P/OF TECHNOLOGY
John M. Davis 205-544-7600

Cases (Controls, Astrophysics, and Structures Experiment in Space) and P/OF (Pinhole/Occulter Facility) are MSFC initiatives that enjoy a tremendous heritage over the past several years in several research areas including the application of Control Structures Interaction (CSI) Technology to large space experiments and the ability to simulate the performance of hard x ray telescopes through the use of the Marshall Hard X Ray Imaging Telescope Simulations (MAHXIS) which uses the Astronomical Image Processing System (AIPS). The P/OF is an excellent candidate for employment either on the lunar surface or as a free-flyer in solar or Earth orbit. The objectives of this RTOP are to continue the development of CASES/P/OF technologies in the areas of software development; i.e., upgrading MAHXIS to support HESP, HEIDI, and Solar 1, in the design and implementation of large lightweight structures capable of easy assembly, and in the identification of the optical, electromechanical and materials technologies that will be required by lunar based instruments. The feasibility of combined end-to-end simulations with CSI and MAHXIS in the loop will be examined. Several initial inhouse conceptual studies of the Lunar P/OF have been accomplished at MSFC. In addition, excellent progress has been achieved with MAHXIS toward simulating HEIDI and HESP (High Energy Solar Physics) type telescopes. These efforts are the foundation for proposed in-depth inhouse and contracted systems studies to develop several detailed concepts. The overall systems study of the Lunar P/OF will include definitions of systems and subsystems of the telescope using MAHXIS to maximize telescope performance.

W92-70199 **170-38-52**
Goddard Space Flight Center, Greenbelt, MD.
GROUND-BASED SUPPORT OF SOLAR PHYSICS
Brian R. Dennis 301-286-7983

The major objectives of this program are listed. The first is to obtain and analyze observations of solar velocity and magnetic fields, global oscillations and wave motions, coronal holes, active regions, and flares at wavelengths observable from the ground. These observations complement UV, EUV, X ray, and gamma ray observations made from NASA spacecraft, sounding rockets, and balloons. The second is to support operational planning for flight-mission experiments and to measure solar inputs for predicting space environment parameters needed for orbital flight dynamics and manned mission activities. The last is to conduct basic research and develop specific instrumentation and observational programs relevant to objectives for future flight missions. The National Solar Observatory's (NSO) Vacuum Telescope at Kitt Peak, Arizona is supported by the Laboratory through its Southwest Solar Station. High resolution, full disk magnetograms, and He I 10830 A spectroheliograms are routinely obtained and substantial observing time is dedicated for special purpose programs of spacecraft support and basic research by Laboratory staff. Solar oscillations are observed during campaigns in the Antarctic with high spatial resolution instrumentation which has been modified and is being placed into regular service at the Vacuum Telescope. Collaborative instrumentation and research programs are initiated and maintained with the National Solar Observatory and other colleagues.

W92-70200 **170-38-53**
Goddard Space Flight Center, Greenbelt, MD.
THEORY, LABORATORY AND DATA ANALYSIS FOR SOLAR PHYSICS
Gordon D. Holman 301-286-4636

The primary objective of this RTOP is to support the laboratory's on-going programs by developing techniques for the interpretation of solar data. The primary goal is to correctly interpret the nature of observable solar phenomena by understanding the fundamental physical processes. This involves obtaining an understanding of the conversion of mechanical energy associated with photospheric velocity fields into a nonthermal energy flux, the propagation of this nonthermal energy from its point of generation to the chromosphere and corona, and the release of this energy in the chromosphere and corona. The focus is on the following areas: (1) the calculation of atomic transition probabilities and studies of nuclear and atomic collision processes in solar plasmas; (2) the development of techniques for determining the strength and structure of the solar magnetic field, from subphotospheric to coronal; (3) determining the physical processes responsible for the conversion of mechanical energy to coronal heating and the driving of the solar wind; (4) determining the physical processes responsible for heating, particle acceleration, and transport in solar flares; and (5) the consolidation of the above processes (1 to 4) into models that predict new solar phenomena and explain those already observed. The work utilizes and impacts observations of the sun across the entire electromagnetic spectrum, from radio frequencies to gamma rays.

W92-70201 **170-38-53**
Marshall Space Flight Center, Huntsville, AL.
UNDERSTANDING OBSERVED SOLAR MAGNETIC FIELDS
R. L. Moore 205-544-7613
(170-38-52)

The general objective is to determine and understand basic empirical properties of solar magnetic fields and their effects in the solar atmosphere. The general approach is to analyze MSFC vector magnetograms along with complementary data from solar space missions and from ground-based observatories, and to interpret observed effects with physical models. The results will guide choices of specific observing programs for future solar space missions, including SOLAR-1, SOHO (Solar and Heliospheric Observatory), and OSL (Orbiting Solar Laboratory). The following studies are pursued: (1) Active regions: form and action of the magnetic field in flares and coronal mass ejections, and magnetic canopies of sunspots; and (2) Quiet regions: fine-scale magnetic structure of the network and its implications for the heating of the transition region and corona; microflares and their relation to coronal heating and spicules; and Alfven-wave trapping and heating in coronal holes.

W92-70202 **170-38-53**
Marshall Space Flight Center, Huntsville, AL.
ANALYSIS AND MODELING OF SOLAR CONVECTION ZONE DYNAMICS AND THE SOLAR CYCLE
D. H. Hathaway 205-544-7610

The objective of this RTOP is to develop an understanding of the dynamics of the solar convection zone and the nature of the solar activity cycle. The approach is to analyze data to determine how the Sun behaves and then use numerical models to emulate this behavior on a computer. Data from instruments like the Solar Oscillations Imager (SOI) on the SOHO (Solar and Heliospheric Observatory) spacecraft will be analyzed to determine the characteristics of the flows within the solar convection zone. Data from historical records of sunspots will be examined to find detailed information about the behavior of the sunspot cycle. Computer programs will be developed to model the dynamics of the solar convection zone with imbedded magnetic fields.

W92-70203 **170-38-53**
Marshall Space Flight Center, Huntsville, AL.
DEVELOPMENT OF A BALLOON-BORNE VECTOR MAGNETOGRAPH
M. J. Hagyard 205-544-7612
(170-38-52)

The objective of this program is to develop the design for a high precision solar vector magnetograph to study flare related solar magnetic fields from a high altitude balloon. MSFC scientists have designed a space-based solar vector magnetograph to measure the photospheric magnetic field as accurately as present technology allows. A ground-based prototype of this flight vector magnetograph is presently under development at MSFC, the Experimental Vector Magnetograph (EXVM). In this Research and Technology program, a design study will be undertaken to determine how the EXVM can be modified to fly on a long duration balloon mission. Engineering studies will be performed on several subsystems of the EXVM instrument that pose particular problems for a balloon-mission vector magnetograph.

W92-70204 **170-38-53**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
MEASUREMENT OF ELECTRON COLLISION PARAMETERS FOR SOLAR PLASMA PHYSICS
R. Goldstein 818-354-0241

The purpose of this task is to measure electron-ion excitation collision strengths needed to interpret solar plasma properties such as electron density and temperature, and ion formation temperatures (freezing in temperature). Use is made of the electron-energy loss method pioneered at JPL, using merged electron and ion beams, trochoidal energy analysis, and spatial detection of electrons using a microchannel plate.

Advanced Programs

W92-70205 **186-06-01**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
TOPS: TOWARDS OTHER PLANETARY SYSTEMS
C. Elachi 818-354-5673

The TOPS (Towards Other Planetary Systems) RTOP encompasses all of the developmental elements and tasks of the program to discover planetary systems and their subsequent characterization. In order to achieve these objectives, assembly of a long term program spanning two decades is required that proceeds in steps allowing milestones at which evaluations of past results can be made to realign the program's direction when necessary. Currently, the program has been divided into four sequential TOPS phases. (1) TOPS 0, is the ground-based phase to be built around the second Keck telescope and implemented immediately (FY-93). It is based on current observational techniques and require no new technology development. Its goal is the detection of disks and planets larger than Jupiter. (2) TOPS 1, is the near term (new start in approximately FY-98) earth-orbital astrometric mission planned to obtain the next level of detailed results, detection of Neptune class planets that will allow testing the planetary formation theories. (3) TOPS 2, is a major class of earth-orbital mission that will take the next step and detect earth-class planets and begin their definitive characterization. The question of possible other life will be answered with spectroscopic analysis of planetary atmospheres. (4) TOPS 3, is an ambitious undertaking that will emplace a large planet detection instrument in the moon that will handily accomplish the TOPS 2 mission goals and penetrate deeper into space observing larger number of stars in search of other planets.

W92-70206 **186-30-00**
National Aeronautics and Space Administration, Washington, DC.
FUTURE DIRECTIONS FOR PLANETARY SCIENCE
Dudley McConnell 202-453-1586

The objective of this program is to support and enhance the U.S. planetary exploration through a variety of research, programmatic, and communications activities. The strategic factors that govern the future course of the planetary exploration program are addressed so as to better understand and anticipate those forces. The results and insights thus obtained will relate to the formal programmatic and scientific processes through which the planetary exploration program evolves. The results will be communicated so as to improve understanding of the planetary exploration program's motivations, opportunities, contributions, and direct and indirect effects on national life. The motivating concepts for this effort are: (1) the planetary exploration program serves a wide range of national interests, scientific and otherwise; (2) form these interests into an effective program; and (3) the program must assure that both the scientific and the anticipated non-scientific values of planetary exploration are realized and extracted in a full and effective way. The approach will consist of: (1) basic research into current and historical factors affecting planetary exploration; (2) interactions with government, scientific, professional, education, commercial, cultural, historical, and high technology interests that may benefit from or have an interest in planetary exploration; and (3) preparation and communication via text, graphical materials, and special presentations and contributions for the purpose of transmitting or applying the results of this research in such a manner as to enhance the success and productivity of the U.S. planetary exploration program.

W92-70207 **186-30-21**
Goddard Space Flight Center, Greenbelt, MD.
COMETS, ICE AND DUST
S. Paddack 301-286-9653

The objective of this RTOP is to perform laboratory experimentation and analysis to study the effects of radiation pressure on small space particles. Current theory and preliminary investigations indicate solar radiation can cause the removal from the solar system certain kinds of natural space debris through a rotational bursting mechanism. This study will investigate, by laboratory experiments and theoretical analysis, a phenomenon which was recently proposed as a mechanism which removes from the solar system certain kinds of small celestial bodies. A laboratory setup utilizing optical levitation will be used in this analysis.

W92-70208 **186-58-00**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
MARS EXPLORATION RTOP - 1992
D. S. Pivirotto 818-354-6629

The objective of this RTOP is to initiate Phase 1 studies of a simple Mars network mission, the Mars Environmental Survey (MESUR). The MESUR concept lands multiple surface stations to conduct meteorology and seismic measurements over a period of several earth years, with the basic requirement that at least 18 stations operate simultaneously for a complete Martian year. This RTOP assumes that MESUR will get an FY-96 new start. Mission and system design studies will be initiated, building on the Pre-Phase 1 work done at the Ames Research Center. Phase 1 contracts will be let for the development of alternative mission and system concepts. Emphasis will be on low cost, including simple designs, commonality between multiply launched payload sets, and low cost launch vehicles. The Phase 1 studies will also address strategies for evolving the simple landed stations and other elements of the mission to: (1) deliver at least three European Space Agency landers, and (2) allow evolution to other types of landed missions, including rovers and sample returns. In a related RTOP, programmatic strategies will be developed for ESA payload delivery and landed payload evolution.

W92-70209 **186-58-00**
Ames Research Center, Moffett Field, CA.
MARS ENVIRONMENTAL SURVEY (MESUR) MISSION CONCEPT STUDY
G. S. Hubbard 415-604-5697

The objectives of this RTOP are to define and develop the mission concept known as the Mars Environmental Survey (MESUR), to define and characterize the strawman science payload (in concert with the MESUR Science Definition Team), and to develop the operational protocols and communications plan which will be used to acquire the MESUR science data from the MESUR landers. MESUR is a mission concept which envisions placing small landers at a wide variety of Mars surface sites, in order to collect meteorological, seismic and surface chemistry data, as well as to obtain images of the Mars surface and information on the structure of the upper atmosphere. Each launch to Mars will deliver four landers, eventually establishing a network of approximately 20 stations scattered globally from pole to pole. Temporary data storage is provided by the lander, as necessary, and transmitted through the medium data rate link to the relay communications orbiter (single orbiter supporting all sites) or with a low data rate direct to Earth. The conceptual studies conducted thus far have identified key mission trade and design areas, and these are being pursued. The approach for this RTOP is to continue the Phase 1 mission design and trade studies including payload definition and communications/operations plans and to prepare the RFP for Phase 2 studies of the MESUR, especially probe design (cruise stage, aeroshell and lander) and the science payload. The goal of the above objectives is to lead the MESUR mission to an FY-95 new start for Phase 3/4.

W92-70210 **186-68-64**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
COMET NUCLEUS SAMPLE RETURN (CNSR)
R. Mitchell 818-354-5152

The primary objective of this RTOP is to maintain continuity, communications, and support with ESA on the CNSR study. There are three main areas to be supported: mission and system studies, Science Definition Team support, and identification of areas where new technology may be beneficial or necessary. The level of activity in each area is necessarily limited because of the scope of the task. In the mission and system area, the approach will be to support the identification of new trajectory opportunities as a consequence of the now delayed launch time, and to provide MMII S/C system consulting in support of the study contracts being led by ESA on the development and integration of the lander and Earth return capsule. At least one Science Definition Team meeting will be planned to maintain the continuity of thought in the science area. Areas of possible new technology being studied by ESA led contracts include autonomous landing with hazard avoidance, sample acquisition and storage, and high speed re-entry to Earth.

W92-70211 **186-68-75**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
NEPTUNE/PLUTO MISSION STUDIES
S. J. Kerridge 818-354-0899

The objective of this RTOP is to continue the definition of the Neptune/Pluto missions, using Mariner Mark 2 spacecraft designs, leading to an FY-96 New Start. This will be a continuing Pre-Phase 1 study following the FY-91 activities. A study lead will be appointed together with a small team of engineers able to carry out the studies required at this stage of project definition. Small teams will be emplaced for spacecraft design, science instrument design assessment, and mission design and navigation. Individuals will be appointed to address science issues (including support of the Science Working Group), operations, research and quality assurance, and other selected areas. Other NASA centers will provide support as appropriate. This includes atmospheric probe studies at ARC, launch vehicle work at LeRC, and, potentially, others. Opportunities for collaboration with other space agencies will be supported, as directed by NASA HQ.

W92-70212 **186-75-00**
Ames Research Center, Moffett Field, CA.
VENUS PRIME PROBE MISSION CONCEPT STUDY
G. S. Hubbard 415-604-5697

The objectives of this RTOP are to define a Pre-Phase 1 Discovery Program mission concept known as the Venus Prime Probe Mission (VPRIME), to define and characterize the strawman science payload and to develop the operational protocols and communications plan which could be used to acquire the VPRIME data. The mission concept envisions delivery of the probe to the atmosphere of Venus on an appropriate small launch vehicle. The mission profile consists of launch into a low earth parking orbit and subsequent insertion onto a transfer trajectory, followed by a direct entry into the Venus atmosphere. After deceleration to subsonic velocity, the main parachute deploys and separates the heat shield from the descent module. Science instruments will function during the descent from an altitude of 70 km to the surface, and data will be transmitted directly to Earth. The system concept consists of a single probe-and-cruise-stage spacecraft launched by an upgraded Taurus or other suitable launcher, capable of injecting 270 kg onto a hyperbolic transfer trajectory with a C3 = 8 sq km/sq s. The science instrument suite consists of a gas chromatograph, a mass spectrometer, and an atmosphere structure experiment. These are advanced versions of the corresponding instruments flown on Pioneer Venus and are estimated to have a combined mass of 19.5 kg and to generate 256 bits of data per sec during the descent phase. The approach for this RTOP is to conduct a Pre-Phase 1 Study and present a feasibility assessment along with supporting cost estimates.

W92-70213 **186-75-03**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
MULTI-MISSION MARS RECONNAISSANCE STRATEGY (MMARS) DEVELOPMENT RTOP - 1992
D. S. Pivirotto 818-354-6629

The objective of this RTOP is to initiate Pre-Phase 1 studies of an evolutionary Mars Reconnaissance Strategy (MMARS) which would evolve from the Mars Environmental Survey (MESUR). The strategy will develop a set of potential missions, including advanced network stations, small rovers, and sample returns. The strategy will include programmatic approaches to a flexible program which can be initiated as funding becomes available. It is expected that such funding would be associated with the Mission From Planet Earth. Mission and system design studies will be initiated, building on the Pre-Phase 1 work done at JPL and JSC in FY-91. Alternative mission and system concepts will be developed. Emphasis will be on low cost, including simple designs, commonality between multiply launched payload sets, and low cost launch vehicles. The studies will interact with the MESUR mission studies to develop strategies for evolving simple landed stations and other elements of the mission to (1) deliver at least three European Space Agency landers, and (2) allow evolution from a network to other types of landed missions, including rovers and sample returns. Programmatic strategies will be developed for ESA payload delivery and landed payload evolution. Technical interchange with ESA will be maintained to facilitate the development of these strategies.

W92-70214 **186-75-13**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
DISCOVERY MISSION STUDY
R. M. Jones 818-354-7769

The objective of this RTOP is to investigate the feasibility of Discovery Class missions to Venus and Mars for code SL. For the purposes of this RTOP, feasibility is demonstrated by a positive answer to the following question: that of scientifically supportable and technically credible missions to Venus and Mars consistent with the goals and constraints of the Discovery program. The approach will be to study a mission to Venus and Mars. These studies will include discussions with appropriate members of the science community (defined by HQ) to define the science objectives for the targets of interest. Conceptual mission, spacecraft and instrument design will be performed to a consistent level. Conceptual project implementation plans and cost estimates will be created and compared to the goals and constraints of the Discovery program to address feasibility.

W92-70215 **186-76-01**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
LUNAR OBSERVER
K. T. Nock 818-354-2153

The objectives of this RTOP are to: (1) re-staff and organize development flight project office; (2) develop mission, spacecraft and ground systems and science instrument definition in sufficient detail to prepare the project definition and cost estimates for a NASA Definition Review in accordance with NASA NMI 7120.3: called a non-advocate review (NAR); (3) generate class-A cost estimates for the Definition Review; (4) release Lunar Observer experiment announcement of opportunity (AO); and (5) support NASA HQ in the preparation for FY-94 new start briefings (Prepare FY-93 preproject plans). The approaches are to: (1) form preproject mission, systems and instrument design teams; (2) place GE-ASD under contract to begin conceptual spacecraft system design and implementation study and instrument accommodation studies; and (3) follow NASA HQ Level 1 Requirements and generate derived Project guidelines, constraints, and requirements.

Solar Terrestrial and Astrophysics SR&T

W92-70216 **188-41-22**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
RELATIVITY, COSMOLOGY, AND GRAVITATIONAL RADIATION
H. D. Wahlquist 818-354-2538

The objectives of these tasks are theoretical and observational investigations of cosmic gravitational waves to define sources, strengths, and detection methods, and planetary radar and lunar laser ranging observations to study the relativistic dynamics of the solar system. In FY-92, the relativity program will: (1) continue studies of the continuous gravitational wave background using millisecond pulsar data and interferometer technology for gravity wave detection in space; (2) develop signal processing methods for very low frequency gravitational wave searches and continue research on gravitational wave astronomy and cosmology including a new geometric formulation of moving frame analysis to be applied to the theory of rigidly rotating self-gravitating fluid spheroids; and (3) support observational tests of relativistic gravity theory, including geodetic precession and possible time variation in the gravitational constant, using planetary ranging and lunar laser ranging.

W92-70217 **188-41-23**
Goddard Space Flight Center, Greenbelt, MD.
OPTICAL TECHNOLOGY FOR SPACE ASTRONOMY
George Sonneborn 301-286-3665

Space based instrument systems for astronomy offer scientists many important advantages. In space, optical systems escape detrimental atmospheric effects such as absorption and turbulence, allowing observations in previously inaccessible spectral ranges and the potential to measure ultra-faint and ultra-small objects. However, the technologies for space optics are fundamentally different than those for ground based systems. Technology developments for space optics specifically must address the expanded spectral region (X rays to far-IR), the vacuum environment, zero gravity, contamination, radiation damage, and the severe weight and volume constraints placed on payloads. The objective of this research and technology program, therefore, is to conduct investigations in those technology areas generic to the development of astronomy instrumentation for space. Relevant technical areas include optical system design and analysis, optical materials, optical fabrication, optical testing, mirror technology, and diffraction grating technology. Investigations are presently being

conducted in 2 technical areas that will have substantive cost/performance payoffs. In optical materials research, major emphasis was placed on ultraviolet mirror coating developments to improve system throughput. In the area of diffraction grating technology, studies of advanced design, fabrication, and testing methods are being conducted.

W92-70218 **188-41-23**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
TECHNOLOGY DEVELOPMENT FOR UV/VISIBLE ASTROPHYSICS
M. Shao 818-354-7834

The objective of this task is the development of advanced observational techniques for application to future space and lunar optical stellar interferometers, including OSI (Orbiting Stellar Interferometer), proposed as a moderate mission for the end of this decade, as well as for LOI (Lunar Optical Interferometer), proposed as part of the Space Exploration Initiative. The design of both of these instruments draws strongly on the ground-based Mark III optical interferometer, an operational Michelson stellar interferometer at Mt. Wilson, and the only instrument of its kind in the U.S. This includes not only the instrument design: configuration, aperture, etc., but also the mission design: observing strategy, sequencing, data reduction, etc. Thus, the approach is to continue observations and data analysis with the Mark III interferometer in order to develop improved observational methods and data reduction techniques. The scientific productivity of the Mark III has improved enormously with increased observational experience; it is important to continue these observations so that those lessons can be applied to the space missions, where the learning process is much more expensive, in order to maximize their scientific productivity.

W92-70219 **188-41-24**
Goddard Space Flight Center, Greenbelt, MD.
ULTRAVIOLET DETECTOR DEVELOPMENT
Bruce E. Woodgate 301-286-5401

The objective of this RTOP is the development of photon-counting detectors and CCDs suitable for future space astronomy missions such as LYMAN, second generation ST instrumentation, the Ultraviolet Imaging Telescope on ASTRO and other Shuttle payloads. The detectors will be sensitive to far ultraviolet radiation, and have both a large format and high spatial resolution. Work at Stanford University under the direction of Dr. Timothy will be directed to improving internal efficiencies and the readout method and to reducing the effective pixel size of the Multi-Anode Microchannel Array (MAMA) detector. Ball Aerospace System Group (BASG) will develop hybrid circuitry for use in a miniaturized 1024 x 1024 square pixel MAMA detector.

W92-70220 **188-41-24**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
ASTRONOMY DETECTOR DEVELOPMENT
P. Grunthaner 818-354-0360

There are two subtasks within this effort: Subtask 1: The objective of this task is to investigate the stability of alkali metal films, also known as Woods filters, which provide the basis for far ultraviolet bandpass filters with substantial rejection of long wavelength red leaks. Such filter technology is required for the effective use of charge coupled devices (CCDs) for far ultraviolet imaging astronomy from space. The major emphasis will be the investigation of the effect of substrate, film deposition conditions, and under- and overlayers on the stability of these alkali metal films. The approach involves designing and implementing a dedicated process station for the production of alkali metal filters, the production of a series of sealed filters with a variety of under and over coatings, and the testing of these filters for transmission, reflection, and uniformity. A contract has been issued to SAIC for this effort. This subtask is to be completed in FY 92. Subtask 2: This task involves a collaboration with EG and G Reticon to develop the technology for high quantum efficiency CCD imagers operating from 100 to 3500 Angstroms. The objective is to produce stable, broad band CCDs with improved quantum efficiencies limited primarily by reflectivity losses at the silicon surface. The approach is to use the atomic layer control of molecular beam epitaxy (MBE) to incorporate a sharp p+ doped epitaxial silicon layer (0.3 to 3 nm thick) near the back surface of thinned CCDs prior to bonding and packaging. Theoretical modeling has shown that this epitaxial layer will effectively eliminate the backside potential well that traps the carriers generated by ultraviolet radiation. This subtask is to be completed in FY 94.

W92-70221 **188-41-51**
Goddard Space Flight Center, Greenbelt, MD.
UV ASTRONOMY AND DATA SYSTEMS
A. V. Sweigart 301-286-6274

The objectives are to perform theoretical and observational astronomical research of particular importance for space observations; to develop and use new instrumentation for imaging and spectroscopy of astronomical objects; to utilize image processing programs on Goddard computers; to develop tools and techniques which will facilitate and improve the reduction, analysis and understanding of astronomical data, primarily through the application of computers for managing large blocks of bibliographical and observational information, including digitized images and spectra, obtained at all wavelengths for stars, galaxies and other extended objects; to support an optical telescope observatory for testing research ideas for space projects; and to develop new instrumentation for observing astronomical objects. The approach used includes the following: (1) obtain detailed stellar evolutionary models for interpreting space observations, particularly those to be made with the Hubble Space Telescope; (2) perform appropriate ground and space observations to study stars, nebulae, the interstellar medium and extragalactic objects; (3) perform theoretical studies in support of space observations; (4) develop and use new instrumentation for imaging and spectroscopy of astronomical objects; (5) develop and utilize image processing programs on Goddard computers; (6) develop tools and techniques for using astronomical data bases (incorporate new astronomical data sets and maintain currency of the databases via journal searches); (7) Develop suitable instrumentation for and maintain the NASA/GSFC 36 inch telescope (utilize the facility to check out new instrumentation leading to flight hardware, to test new observational techniques, and to provide support data for spacecraft observations); and (8) Produce a grid of absolute flux standards for future NASA missions.

W92-70222 **188-41-53**
Goddard Inst. for Space Studies, New York, NY.
STELLAR EVOLUTION AND PULSATION
Richard Stothers 212-678-5605

The general objectives are to achieve a better understanding of the evolution of massive stars from the main sequence to the pre-supernova state and to establish more firmly those properties of Cepheids and Cepheid-like variables that are useful for stellar evolution studies and for galactic and extragalactic distance studies. Applications in progress are expected to produce improved information on the extent of convective core overshooting in bright stars both on and off the main sequence. Massive stars and Cepheid variables are useful focuses of study because of their crucial importance in various problems in galactic and extragalactic research. A combination of theoretical numerical modeling and of comparison of the models with observed stars is the main approach being adopted. The fully nonlinear equations of quasistatic evolution and of hydrodynamical pulsation are applied to calculate the models and thus to predict the surface properties that can be compared with observations.

W92-70223 **188-41-53**
Goddard Inst. for Space Studies, New York, NY.
RESEARCH IN ASTROPHYSICS: SOLAR SYSTEM, TURBULENCE
Vittorio M. Canuto 212-678-5571

The objectives of this program are the study of the phenomenon of Large Scale Turbulence (LST) and its implications in astrophysics. The great diversity of physical settings (geophysics,

atmospheric physics, origin of planets, accretion disks in general, molecular clouds, etc.) in which a detailed knowledge of turbulence is needed, is in stark contrast with the lack of analytical models sufficiently general to be applicable to the above cases. Since the only available methods are either phenomenological expressions or numerical simulations of the full hydrodynamic equations, (neither of which is satisfactory), constructing an analytical model for LST is an objective. The approach uses as the only ingredient for both the energy source as well as for the cascade integral the growth rate of the unstable modes that ultimately generate turbulence. The results thus far fare very satisfactorily with a large variety of laboratory data.

W92-70224 **188-41-57**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
LABORATORY ASTROPHYSICS
J. M. Ajello 818-354-2457

This objective includes Laboratory Astrophysics studies of electron impact cross sections and lifetimes of cosmically abundant atoms, molecules and their ions conducted at JPL. The resulting data are available for analysis of Hubble Space Telescope and Lyman Explorer observations of UV spectra. The laboratory data will be generated by performing experiments using: (1) electron impact excitation to measure UV fluorescence spectra at high spectral resolution; (2) electron energy loss, merged-beams to measure absolute collisional excitation line strengths in single and multiple charged ions; and (3) lifetimes at high time resolution. The principal application of these atomic and molecular parameters are to model observations of diffuse molecular clouds, the interstellar medium and stellar atmospheres.

W92-70225 **188-44-01**
Goddard Space Flight Center, Greenbelt, MD.
RESEARCH COMPUTING FACILITY AND CATALOGING FOR INFRARED
N. W. Boggess 301-286-6989

The scientific objectives of this program are to enhance the ability to interpret observations and continue updating catalogs of infrared observations for the benefit of the astronomical community. This program will maximize scientists' ability to interpret observations and provide information for efficient observing programs. Tools and techniques which will facilitate and improve data reduction, analysis, and understanding of astrophysical data are being developed. The cataloging effort is made available to the scientific community at large, and the computing facilities are made available to visiting scientists.

W92-70226 **188-44-01**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
ASTROPHYSICS SUPPORT
P. Swanson 818-354-3273

This RTOP provides general support to the astrophysics program office to fund outstanding visiting scientists for collaborative efforts with NASA, special meeting support and other ad hoc assignments for which no specific RTOP applies.

W92-70227 **188-44-21**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
INFRARED/RADIO RESEARCH
P. Wannier 818-354-3347

The objectives of this research are to carry out radio and infrared observations and analysis relating to galactic and extragalactic astronomy. The facilities used include NASA's deep space network and the research relates to such future space missions as Space Infrared Telescope Facility (SIRTF), a submillimeter mission (SMMM) and orbiting Very Long Base Interferometry (VLBI).

W92-70228 **188-44-23**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
SUBMILLIMETER ASTRONOMY
T. B. H. Kuiper 818-354-5623
(188-44-21)

The objectives of this activity are to study the interstellar medium using very high spectral resolution astronomical observations of molecular and atomic transitions. The observations will probe the physical conditions in molecular clouds, star forming regions, and circumstellar envelopes of late-type stars. Millimeter and submillimeter wave spectral lines provide diagnostics of cold molecular clouds, and of very dense, warm molecular gas as it interacts with stellar objects: protostars, T-Tauri stars, and late-type stars. Measurements of interstellar molecules at frequencies where the terrestrial atmosphere hinders observation are essential to understand the evolution of molecular clouds and star formation. Besides the intrinsic difficulty of making such observations, this part of the spectrum has been largely unexplored because the required technologies are still in their infancy. This activity places strong emphasis on the development and use of state-of-the-art superconductor insulator superconductor (SIS) heterodyne receivers. One task addresses the determination of the abundance of interstellar H2O-18, and by implication, H2O. Airborne observations of dense molecular cloud cores are planned for 1992. The other task addresses the determination of the abundance of interstellar O2. Balloon observations will be made of a variety of molecular clouds and star forming regions in order to determine how the abundance of O2 varies as clouds evolve. These activities lend strong support to future spaceborne submillimeter wavelength astronomical missions based on high spectral resolution (heterodyne) spectroscopy. This research focuses on observations from very high mountain tops (e.g., Mauna Kea at 4.1 km) during exceptional conditions, from the NASA airborne observatory (up to 12.5 km), and from balloons (up to 42 km). A 547 GHz receiver is being constructed for use on the Kuiper Airborne Observatory in 1992. A receiver system operating at 119 GHz will be flown with the UCSB balloon-borne 1 m telescope. The receiver will have a single sideband system temperature of less than 100 K. The angular resolution will be 12 feet. An engineering flight is planned for Sep./Oct. 1991. The first data flight will be in Mar./Apr. 1992.

W92-70229 **188-44-23**
Ames Research Center, Moffett Field, CA.
INFRARED AND RADIO ASTROPHYSICS TECHNICAL DEVELOPMENT: GROUND-BASED ASTRONOMICAL INSTRUMENT
T. L. Roellig 415-604-6426

The objective of this RTOP is to develop advanced technology for use in infrared and radio astronomical instrumentation. The technology being developed under the tasks at NASA-ARC will be utilized at ground-based observatories in a wide variety of astrophysical studies, including imaging of planetary, galactic, and extragalactic objects. As part of this program, two instruments will be constructed, one a photometer cooled by adiabatic demagnetization refrigeration that will be used at submillimeter wavelengths (ADRPH) and the other a large format infrared camera capable of being used in the 10 and 20 micron atmospheric windows (AIRC). The approach of this RTOP is to build on existing technology and facilities here at NASA-ARC, extending the technology beyond the developmental stage to allow it to be employed in useable, state-of-the-art, astronomical instrumentation.

W92-70230 **188-44-23**
Goddard Space Flight Center, Greenbelt, MD.
INFRARED, SUBMILLIMETER, AND RADIO ASTRONOMY
N. W. Boggess 301-286-6989

The scientific objective of this program is to provide a better understanding of the current state and evolution of the universe as a whole and of specific objects within it. This is achieved by making, analyzing, and interpreting observations at wavelengths from 1 micron to 1 mm and at a wide range of spectral resolving powers. Since atmospheric opacity and emissivity prohibit it or severely limit ground-based observations at certain wavelengths, high altitude platform such as the Kuiper Airborne Observatory, balloons, or satellites must be used. High sensitivity composite bolometers are being developed in the far infrared to take maximal

advantage of low background conditions at those altitudes. A balloon-borne 1.5 m telescope is used to measure the small scale anisotropy of the cosmic background radiation, an infrared camera is used to image efficiently galactic and extragalactic sources.

W92-70231 **188-44-24**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
ADVANCED IR AND RADIO ASTRONOMY DETECTOR DEVELOPMENT
M. A. Frerking 818-354-4902

This RTOP covers two tasks: development of a 1036 GHz receiver for astronomy and development of a near IR imaging camera for use at the Palomar Observatory. The original objective of the first task was to demonstrate in the laboratory a heterodyne receiver operating above 1000 GHz using components baselined for SMMM; ' superconductor insulator superconductor' (SIS) tunnel junction mixers and solid state local oscillators. Due to lack of funds, that objective has been descoped to address the key technical issues associated with SIS heterodyne receiver operation above 1000 GHz. It is requested that the proposal be funded at its original level if overguideline monies are available. The task has two development elements; the SIS tunnel junction mixer and the solid state local oscillator. The mixer task will determine the response near 1000 GHz of high-Q superconducting embedding circuits for SIS mixers. The local oscillator task will fabricate a multiplier chain driven by a Gunn oscillator. The effort is being carried out jointly at the JPL and the University of Massachusetts (U of Mass.) The development of the SIS tunnel junction mixers is the responsibility of JPL. The development of the solid state local oscillator is the responsibility of the U of Mass. and funded under a separate RTOP. The scope of the task has been changed due to the funds available. The budget for the original proposal was about $260K/year. The allocated funds were $100K/year. Should additional funds become available, the scope of the program will be enhanced. The second task is the use of a near-IR camera at Palomar to view a number of galactic and extragalactic sources in the 1 to 2.5 micron spectral region using the 5 m telescope. A 256 x 256 HIRIS array of HgCdTe detectors was used in the camera during the past year. The first array installed had severe cosmetic problems and was successfully replaced by a second array with much better cosmetic appearance. Final performance values for the array include a peak quantum efficiency of 25 percent and a read-noise of about 1500 electrons. On the software side, great progress was made in developing IRAF and IDL routines to reduce the effects of noise-pickup in the data, and flat field, calibrate and mosaic camera images for final analysis.

W92-70232 **188-44-24**
Marshall Space Flight Center, Huntsville, AL.
ADVANCED ASTROPHYSICS SYSTEMS STUDIES
Charles M. Telesco 205-544-7723

The objectives are as follows. The first is to contribute to the NASA Astrophysics Research Program by the continuing development and the use of advanced infrared detector systems in observatories in order to increase the basic understanding of the detector operation, optimization, and applicability to advanced observatories on the ground, in space, and in the lunar environment. The next is to utilize the talents of MSFC in-house personnel and laboratory capabilities and to collaborate with other NASA centers and outside institutions in the use of existing state-of-the-art MSFC IR arrays and the well focused development of new thermal-IR arrays. These IR arrays will be used to work at the frontier of IR astronomical observing, thereby determining the capabilities of these arrays under realistic operating conditions.

W92-70233 **188-44-53**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
THEORETICAL INFRARED/RADIO RESEARCH
D. L. Meier 818-354-5062

The purpose of this research is to support the NASA space-based and ground-based observations in the radio and millimeter regions of the spectrum with theoretical work to improve the understanding of atomic and molecular processes in interstellar clouds and to improve the understanding of hydrodynamical and magnetohydrodynamical processes in radio sources. In FY 92, in the theoretical interstellar chemistry area, these programs will study NH3 and CH3OH in interstellar cloud mantles and cores, model spatial correlations of OH and CO in the outer regions of dark clouds, and develop a Monte Carlo radiative transfer code for modeling the high optical depths of submillimeter hydride emission lines with realistic cloud kinematics and geometry. In the theoretical radio source area these programs will port the MHD jet and accretion disk simulation code to the new Caltech Intel Touchstone DELTA parallel supercomputer and perform an intensive study of magnetic accretion disks and their potential for producing, collimating, and accelerating jets, with special emphasis on extremely CPU- and data-intensive calculations on the DELTA.

W92-70234 **188-44-53**
Ames Research Center, Moffett Field, CA.
THEORETICAL STUDIES OF GALAXIES, THE INTERSTELLAR MEDIUM, MOLECULAR CLOUDS, STAR FORMATION
B. F. Smith 415-604-5515

The objective of this research is to better understand: (1) the formation and evolution of galaxies and clusters of galaxies; (2) basic processes which determine the state and infrared radiative properties of the interstellar medium in galaxies; (3) molecular clouds and star formation; and (4) the structure and evolution of the atmospheres of evolved stars. This research is being stimulated by observational advances and expected capabilities of new NASA observational programs. The approach of this effort involves theoretical analyses and computational astrophysics employing a wide variety of numerical codes developed at Ames to treat fundamental problems in the areas of interest. These numerical codes treat multi-dimensional hydrodynamic and magneto-hydrodynamic fluid problems, multi-dimensional particle problems, and complex chemistry and radiative transfer situations. This effort makes effective use of the advanced computational facilities at Ames.

W92-70235 **188-44-53**
Goddard Space Flight Center, Greenbelt, MD.
THEORY AND MODELING: INFRARED, SUBMILLIMETER, AND RADIO
N. W. Boggess 301-286-6989

The scientific objectives of this program are to provide a better understanding of the current state and evolution of the universe as a whole and of specific objects within it. This is achieved by conducting theoretical and analytical studies, including sophisticated modeling, in which the emphasis is on examining effects in the wavelength range 1 micron to centimeters. Tools and techniques which will facilitate and improve theoretical analysis and enable maximum insight into the understanding of astrophysical data are being developed.

W92-70236 **188-44-57**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
LABORATORY ASTROPHYSICS
H. M. Pickett 818-354-6861

The objective of this work is to make measurements and provide laboratory data in support of NASA's missions in astrophysics, particularly those missions using molecular signatures in the infrared, far infrared, submillimeter and microwave regions of the spectrum. In one thrust of this research, primary spectral data is obtained in the laboratory, and theoretical models based on this and other data are cataloged and made available to the general astrophysics community. These cataloged results are then used for both planning and interpreting observations with either airborne or spaceborne instrumentation. A second thrust of this laboratory astrophysics work involves measurement of ion-molecule reactions and their interpretation. Radiation association reactions are a class of ion-molecule reactions important in the evolution of interstellar gas clouds. The aim is to study these reactions in the laboratory and develop methods of predicting the importance of similar reactions that are not measurable in the laboratory.

W92-70237 **188-44-57**
Ames Research Center, Moffett Field, CA.
PROPERTIES OF INTERSTELLAR PAHS
L. J. Allamandola 415-604-6890

The objective of this RTOP is to understand why free, molecular sized, polycyclic aromatic hydrocarbons (PAHs) are surprisingly abundant in many different astronomical objects. They are a widespread, previously unrecognized component of the interstellar medium and play a dramatic role in determining many properties such as energy balance, molecular cloud temperature and chemistry, and carbon dust particle formation. The approach of this RTOP is to increase knowledge of the spectroscopic, physical and chemical properties of PAHs in the forms they are likely to be in, in space: ions, radicals, neutral species and clusters. Spectroscopic properties of these unique species are particularly important to know since all telescopic data pertaining to this problem are spectroscopic. The major goal of this research is to provide the data necessary to test the PAH hypothesis and further the understanding of the roles of PAHs in astrophysics. Experiments are underway in the laboratory in which PAHs are prepared under conditions which duplicate, as much as possible, the interstellar conditions in which they are found.

W92-70238 **188-44-57**
Goddard Space Flight Center, Greenbelt, MD.
LABORATORY ASTROPHYSICS
J. Nuth 301-286-9467

The overall objective of this program is to obtain laboratory measurements of quantities and processes which can lead to a better understanding of astrophysical systems. As part of this general objective, both theoretical analyses and studies to model appropriate systems are undertaken. The objectives of the specific tasks supported under this RTOP are: (1) to obtain high resolution spectra (one part in 10(exp 7) of isotopically labeled molecules in sufficient detail to construct energy level diagrams of individual vibrational states; (2) to determine the pre-condensation cluster distribution leading to the nucleation of refractory circumstellar particles; (3) to determine the spectra of amorphous grains of various compositions for comparison with interstellar/circumstellar dust; (4) to obtain far-infrared spectra of various ices and grains for comparison with astrophysical observations using SIRTF and SOFIA; and (5) to understand the evolution of organic/metallic ice grains as a function of chemical composition and degree of irradiation and warmup. Data required to achieve the above objectives will be obtained using a variety of experimental techniques and equipment. In particular, objective (1) will be accomplished using a combination of tunable diode lasers and Fourier Transform Spectrometers (FTS). Objective (2) will be accomplished using a unique dust generator built at GSFC and a combination of annealing/hydration systems, a UV-visible spectrometer and an FTIR spectrometer. Objective (4) requires use of a low-T cryostat and FTIR while (5) requires both of these systems, plus a 1 MeV proton accelerator.

W92-70239 **188-44-57**
Goddard Inst. for Space Studies, New York, NY.
CALCULATION OF MOLECULAR COLLISION RATES OF ASTROPHYSICAL INTEREST
Sheldon Green 212-678-5562

Molecular collisional excitation rates are needed to understand energy balance in the interstellar gas and to model spectral line formation in these regions. Detailed knowledge of these parameters is required to interpret astrophysical observations at millimeter, submillimeter, and infrared wavelengths. Despite much effort and some progress, none of the relevant rates have yet been obtained experimentally, and most of the current knowledge comes from theoretical studies. Theoretical determination of these rates requires information about the intermolecular forces and calculation of collision dynamics; both of these can now be obtained with some accuracy by solving equations of quantum mechanics, and theoretical values for many systems have been calculated and used in analyzing radioastronomical data. As observations are pushed to higher frequencies, the required values become more difficult to calculate owing to the increased number of quantum levels which must be considered. The present work aims at improving current methodology and developing new approximate methods to obtain collision rate constants of current and anticipated relevance to submillimeter and infrared observations.

W92-70240 **188-46-01**
Ames Research Center, Moffett Field, CA.
THEORETICAL STUDIES OF ACTIVE GALAXIES AND QUASI-STELLAR OBJECTS (QSOS)
F. C. Witteborn 415-604-5520

The objective of this RTOP is to understand the origin of the continuum spectra of compact, luminous objects such as active galactic nuclei. An optically thick, relativistic outflow is believed to arise in the core of these objects. The evolution of the distribution functions of the photons and pairs in this core is followed from an arbitrary start until a characteristic spectrum is reached or until the spectrum freezes out. The emergent electron-positron photon spectrum is compared directly with observations. The interaction of the emergent electron-positron pair wind is modelled and its predicted radiation is compared with observations. The approach of this RTOP is to model interaction processes which are likely to be important to the spectrum: pair production, pair annihilation, Compton scattering and bremsstrahlung. In addition, synchrotron emission is important in a strongly magnetized plasma. The research will be extended by modelling the dynamics and spectrum of the pair jet which emerges from the optically thick core and feeds a magnetized jet.

W92-70241 **188-46-01**
Goddard Space Flight Center, Greenbelt, MD.
HIGH ENERGY ASTROPHYSICS: DATA ANALYSIS, INTERPRETATION AND THEORETICAL STUDIES
J. F. Ormes 301-286-5705

This RTOP is to support laboratory efforts at processing, analyzing and interpreting the data involving correlative studies from a variety of spaceflight experiments, and to conduct theoretical studies to support this effort. These theoretical and interpretive studies lead to the publication of results in the scientific literature and help in the planning of new missions in the areas of x ray and gamma ray astronomies, energetic particles and cosmological studies. Multisatellite data sets, such as those of Ariel 5, Orbiting Solar Observatory (OSO) 8, High Energy Astronomy Observatory (HEAO) 1 and HEAO 2 provide a basis of information which for many x ray sources remains complementary to the results of recent missions such as European X ray Observatory Satellite (EXOSAT) and Ginga, and upcoming missions such as Roentgen Satellite (ROSAT) and Broad Band X ray Telescope (BBXRT). These data continue to provide important pieces of the still incomplete pictures of the unresolved physical systems that make up cosmic x ray sources, especially when they are compared to other data, either from other x ray observatories, or from space or ground based observatories at other wavelengths. An additional important task is the definition of the manner in which new data will be added to this repository for future work by archival investigators. Strong emphasis is placed on creating the theoretical framework for interpreting the results, using the data to test recent theoretical work, and carrying out studies to test the feasibility of measurements with future missions. This RTOP supports graduate student thesis research, research associates and an occasional senior faculty member on leave from an academic institution.

W92-70242 **188-46-57**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
GAMMA-RAY ASTRONOMY AND TECHNOLOGY DEVELOPMENT
W. A. Mahoney 818-354-6606

In order to avoid source confusion problems, to locate point sources well enough to allow identification with known objects, and to map the steep gradients expected toward the galactic center for diffuse sources, future gamma ray spectroscopy experiments will require greatly improved imaging capabilities over those of past or planned missions. In addition, systems will be

required which can reliably cool the germanium detectors to about 80 K for many years without introducing noise from microphonics. One of these research and analysis tasks involves the development of advanced segmented germanium detectors together with the appropriate coded aperture and Fourier transform masks which will provide the basis for an instrument which will combine good gamma ray imaging capabilities with the energy resolution of germanium detectors. During the multi-year program, a series of segmented germanium detectors will be fabricated with increasingly improved imaging capabilities. The second task involves balloon flight testing of a segmented germanium detector as well as performance evaluation of the detector cooled by a Stirling cycle refrigerator to assure there are no microphonics problems. During FY 91 a second 5-segment germanium detector was fabricated and evaluated. Its background rejection capabilities will be measured during a balloon flight from the Southern Hemisphere in the Fall of 1991. During FY 92 an 11-segment germanium detector having a position resolution of 6 mm will be built. Its performance will be measured with various coded aperture and Fourier transform masks, and the results will be compared with detailed Monte Carlo calculations. During FY 91 tests will be conducted to measure the susceptibility of a coaxial germanium detector to microphonics. During FY 92 a segmented detector will be evaluated while it is being cooled with a Stirling cycle refrigerator at JPL. Segmented germanium detectors will almost certainly be used as the prime sensors in the next space-based gamma ray experiment beyond the Gamma Ray Observatory, and cooling will undoubtedly be provided by mechanical refrigerators. All the technology developed under these tasks will be directly applicable to that mission and to missions beyond.

W92-70243 **188-46-57**
Goddard Space Flight Center, Greenbelt, MD.
GAMMA RAY ASTRONOMY
Carl E. Fichtel 301-286-6281

The technical objective is to develop the most appropriate detector systems for the observation of astrophysical sources of very energetic photons. The first approach was the development of a large high energy telescope using digitized spark chambers. Many major improvements to this basic telescope system have been pursued and other approaches to detector systems are now being developed for high energy, intermediate energy, and low energy gamma-ray observations. In the high energy region, improvements in the track imaging chamber systems are continuing, and special attention in the track imaging chamber research is now being directed towards drift chambers. At the same time, several approaches are being explored to improve angular resolution, including techniques to concentrate on higher energy photons, and sensitivity, including the study of techniques to build much larger systems. Improved approaches to the energy measurement and coincidence system also are being pursued. In the range from 0.5 to 40 MeV, it is apparent that substantial sensitivity improvement will require elimination of the ambiguity produced by conventional Compton telescopes in determining the direction of a detected gamma ray. New detector technology and a new approach is therefore required. For gamma-ray burst studies, new detector systems are being developed both for the gamma-ray energy range and for detection at other wavelengths. In particular, a ground-based system was developed to detect and precisely locate optical flashes that are likely to occur in coincidence with gamma-ray bursts. It is being installed at Kitt Peak National Observatory and will begin operation in May 1991.

W92-70244 **188-46-57**
Marshall Space Flight Center, Huntsville, AL.
GAMMA RAY ASTRONOMY
Gerald J. Fishman 205-544-7691

A program in gamma-ray astronomy is being pursued using balloon-borne experiments and data analysis from previous space-borne missions. Techniques and instrumentation for future space flight experiments are developed concurrently. Various sources of background radiation of interest to gamma-ray astronomy are being studied. The objectives of the MSFC research program are to perform new scientific observations in gamma-ray astronomy using balloon-borne detectors; to develop new detectors and experimental techniques for future space-borne gamma-ray astronomy observations; and to study various sources of background radiation, primarily atmospheric gamma-ray radiation and activation of detectors and materials returned from space in order to increase the sensitivity of gamma-ray observations.

W92-70245 **188-46-58**
Goddard Space Flight Center, Greenbelt, MD.
GAMMA-RAY SPECTROSCOPY
Bonnard J. Teegarden 301-286-5277

The objectives of this effort are to develop new instrumentation to perform high resolution spectroscopy and imaging of celestial gamma-rays in the 0.01 to 10 MeV range and to fly this instrumentation on high altitude balloons to assess the performance in a space-like environment and to gather scientifically meaningful data. In particular, the instrumentation will be designed to search for and measure the properties of narrow lines in the celestial gamma-ray spectrum. A major goal of this work will be the demonstration of new ideas and techniques for the eventual use in a satellite-borne experiment. The approach will center on the use of high purity Germanium detectors to perform the most precise possible measurements of the gamma-ray energy. In addition, new techniques will be explored to further suppress instrumental background and thereby improve the sensitivity of the experiment. Finally, new methods will be explored for constructing images on the gamma-ray sky with an accompanying improvement in angular resolution over earlier experiments.

W92-70246 **188-46-59**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
X-RAY ASTRONOMY CCD
S. A. Collins 818-354-7393

The objective of this task is to develop, in a joint effort with Pennsylvania State University (PSU), a charge-coupled device (CCD) which is suitable for use as an astronomical detector of soft x-rays and to support the use of this detector in a rocket-borne instrument to acquire energy-resolved x-ray images of astronomical sources. This task will be accomplished by designing and fabricating CCDs which combine proven features which provide high sensitivity at photon energies of 0.3 to 2.0 KeV with very low noise (approx. 0.5 electrons, rms) signal readout.

W92-70247 **188-46-59**
Marshall Space Flight Center, Huntsville, AL.
X-RAY ASTRONOMY
M. C. Weisskopf 205-544-7752

The overall objective is to conduct research in the field of x-ray astronomy in areas related to the Astrophysics programs of NASA. The objectives of this program are to design, build, test, and fly imaging proportional counters of advanced design. These instruments will incorporate new techniques developed at Marshall Space Flight Center and will provide a level of performance far superior to conventional instruments. They will have applications in imaging, timing, and spectroscopy. In addition, new techniques for focusing x-rays, particularly at energies above those accessible to current (reflecting) x-ray telescopes, will be explored, as well as new methods for detecting x-ray polarization.

W92-70248 **188-46-59**
Goddard Space Flight Center, Greenbelt, MD.
HIGH THROUGHPUT X-RAY SPECTROSCOPY
F. Marshall 301-286-5279

The Goddard Space Flight Center (GSFC) X-Ray Astronomy Group has repeatedly made major technological breakthroughs that have qualitatively improved capabilities for spectroscopy in the X-ray band. These advances, from proportional counters to X-ray calorimeters to broad-band X-ray optics, have all had their origins in our Space Research and Technology program. We intend a broad-based program to continue this development both by enhancing current technologies and by developing promising new technologies. We plan a systematic program to develop techniques

to approach the intrinsic spatial resolution of conical foil X-ray optics, whose high filling factor and flat-field characteristics are powerful advantages for many investigations. We plan enhancements in X-ray calorimeters, including new technologies for thermometers and absorbers, which may improve their energy resolution by an order of magnitude. With a view farther into the future, we plan to develop Josephson junctions as X-ray detectors. There is the promise of detectors with the spatial resolution of CCDs and the spectral resolution of current calorimeters. A key to our progress in detector and mirror technology has always been and will continue to be the ready availability of the proper calibration facilities. Our current capabilities are becoming inadequate, and we are investigating appropriate upgrades. Finally, we plan the first astronomical observations using X-ray calorimeters in a series of rocket flights. The first flight will provide the first truly high resolution spectroscopic observation of the soft X-ray background. It will test in a fundamental way our understanding of the interstellar medium and, by constraining models for the extragalactic X-ray background, will contribute to our understanding of the evolution of active galaxies and quasars.

W92-70249 **188-78-01**
Marshall Space Flight Center, Huntsville, AL.
LUNAR AND HIGH EARTH ORBIT TELESCOPE STUDIES
Max E. Nein 205-544-0619

The objectives of this RTOP are to conduct system concepts studies of Lunar Telescopes and High Earth Orbit telescopes, to assess the key technologies required to assure timely development of these advanced telescopes and their supporting elements and to conduct technology pilot studies in specific key areas of technology. Initial in-house conceptual studies of a Large Lunar Telescope (LLT), a precursor transit telescope and a high Earth orbit telescope have been accomplished at Marshall Space Flight Center (MSFC) and several research institutions. These efforts are the foundation for proposed in-depth in-house and contracted systems studies to develop several detailed concepts of the telescopes. The overall systems studies of these Observatories will include definitions of the systems and subsystems of the telescopes. Requirements for the transportation to the lunar surface or high Earth orbit will be assessed, and requirements and methods of constructing, establishing, operating, and maintaining the telescopes will be analyzed. The proposed studies will also define the critical program and system trades required to resolve the complex relationships between the observatories, the lunar base and other elements of the space exploration initiative and the operational aspects of a high Earth orbit telescope, which will have to be serviced by robotic systems. Technology driver elements essential to the timely evolution of the Large Lunar Telescope have been identified in the course of current in-house analyses and evaluations of major subsystems comprising the LLT. In the coming year, in-house and contracted studies of (1) key enabling technologies; (2) critical technologies driving designs of the observatories and its elements; and (3) other, lesser technologies contributing to the successful development and operation will be identified and analyzed in specific research and technology tasks described in attached documentation.

W92-70250 **188-78-01**
Goddard Space Flight Center, Greenbelt, MD.
INTEGRAL/NAE MISSION DEFINITIONS STUDY
Neil Gehrels 301-286-6546

The objectives of this effort are to study mission issues relevant to flying high-resolution germanium detectors in space for gamma-ray spectroscopy. The specific missions under consideration are the International Gamma Ray Astrophysics Laboratory (INTEGRAL) and the Nuclear Astrophysics Explorer (NAE). The goal is to address issues of launch, spacecraft, instrumentation and interfaces in order to make such missions feasible.

W92-70251 **188-78-41**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
LAGOS MISSION DEFINITION STUDY
R. W. Hellings 818-354-3192

The purpose of this research is to develop a strategy for future NASA gravitational wave missions, leading up to and including the LAGOS mission. This study will include a science assessment of precursor microwave and Earth-orbiting missions, strawman mission designs for these precursor missions, and technology requirements for all of the missions, with special attention to how the technology results from one mission will lead to technology for the next.

W92-70252 **188-78-41**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
RELATIVITY ADVANCED TECHNOLOGY DEVELOPMENT
R. W. Hellings 818-354-3192

The purpose of this research is to investigate technology issues for missions to test the foundations of relativistic gravitation and to detect gravitational waves, and to qualitatively assess the scientific capabilities of several optical interferometer designs, identifying the technological developments needed to achieve the goal of deploying a high resolution imaging or astrometric instrument in space in the near future.

W92-70253 **188-78-41**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
OPTICAL INTERFEROMETRY IN SPACE
M. D. Rayman 818-354-2544
(188-78-44)

The primary objective of this RTOP is to define an intermediate-class astrometry/imaging interferometry mission for launch early in the next decade. The targeted astrometric accuracy is 3 to 30 microarcsec, and the imaging resolution is to be approx. 5 milliarcsec. In FY-91, basic mission and flight system designs were formulated, science performance was predicted, and preliminary cost estimates were developed. Confidence in the designs will be increased by continuing and refining the study. Emphasis will be placed on challenging areas identified during FY-91, including deployment accuracy and structural and thermal modeling. In addition, new processes for developing credible cost estimates will be devised to aid in the new start review. The response to recommendations of the Optical Interferometry Science and Technology Advisory Group (OISTAG) and variations of the mission studied in FY-91 will be examined, including both increases and decreases in scope. Expected science return, technology requirements, and cost estimates will be defined for each alternative. Guidance from the OISTAG will be sought and used throughout this process, and the recommendations put forth by the Astronomy and Astrophysics Survey Committee will continue to be used in the assessment of the science value. Flight experiment possibilities to demonstrate and validate critical technologies will be identified, and recommendations will be made on how such experiments might be completed prior to the targeted new-start review in FY-97. As part of the FY-91 work, technology requirements and development plans were formulated. The technology plans will be updated, and results of ongoing technology development work will be incorporated into the mission concept. In addition to the study of the intermediate-class mission, a study of the technology required for a follow-on major imaging interferometer will continue. At least two mission concepts will be used, and both enabling and enhancing technologies for the spacecraft platform and science instrument will be identified, quantified, and prioritized.

W92-70254 **188-78-44**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
SPACE INFRARED TELESCOPE FACILITY (SIRTF) MISSION STUDIES
R. J. Spehalski 818-354-3506

The overall objective is to develop telescope, spacecraft, and science instrument technology and requirements in preparation for an October 1991 Project Review, a June 1992 Project Definition

and Cost Review (PDCR) and a FY-94 New Start. Specific objectives include progress toward conceptual design of a Spacecraft, Telescope, and Science Instruments to include Infrared Array Camera (IRAC), Multi-Band Imaging Photometer (MIPS), and Infrared Spectrograph (IRS); conducting a review of soft freeze designs and requirements; continuing technology development of the Telescope and Science Instruments; continuing technology development of Fine Guidance Sensor (FGS); continuing Science Support to include the Science Working Group and support to science instruments; continuing support at Ames Research Center for telescope technology development, science instrument technology support, and science support; continuing support by Goddard Space Flight Center (GSFC) for Infrared Array Camera (IRAC); conducting industry briefings as required to apprise industry of SIRTF progress and status; continuing project and mission engineering studies; and continuing science and mission operation studies.

W92-70255 **188-78-44**
Ames Research Center, Moffett Field, CA.
IR ASTRONOMY ATD/CRYO OPTICAL TESTING AND SCIENCE SUPPORT ACTIVITIES
G. S. Hubbard 415-604-5697

The objective of this RTOP is advanced development of key technology for the telescope of the Space Infrared Telescope Facility (SIRTF). SIRTF is an observatory that will accept multiple focal plane instruments for use by infrared astronomers. Previous studies have identified key technology needed for the telescope and scientific instruments. The continuing technology development includes cryogenic optics and the control of stray radiation.

W92-70256 **188-78-44**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
SUBMILLIMETER OBSERVING SYSTEM DEVELOPMENT
W. B. Gray 818-354-1090

The objective of this study is to define a moderate class submillimeter astrophysics mission, perform trade studies, and develop the requirements and specifications needed to initiate an industry Phase A study in FY-93. The approach has been to develop a point design to evaluate mission feasibility and science return, and to estimate costs. Approaches to enhancing and descoping the mission have been identified. Informal discussions have been held with National Center for Space Studies-France (CNES) and The European Space Agency (ESA) on both the science and mission levels to investigate interest in a collaborative mission. This year a mission will be defined that fits within the moderate mission category, cost estimates made, and the necessary technical data developed to proceed to industry Phase A studies in FY-93. A significant effort will be made in defining optical and sensor systems to meet the mission requirements, and start supporting integration studies to move from component technology toward system demonstrations. Efforts will also continue in defining international collaboration options.

W92-70257 **188-78-44**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
LUNAR SUBMM AND VLF ARRAYS
M. J. Mahoney 818-354-5584

During FY-91 this RTOP identified the unique science goals of a lunar submillimeter array and a very low frequency array, and used these goals to define system requirements, developed conceptual designs which met the requirements, and identified the technology needs of each project. Both arrays require a more in depth study of their imaging capability for potential science targets so as to ensure that the optimum configuration is used. Completing realistic imaging simulations will be the major goal of the FY-92 RTOP. During FY-91 a software package was adapted to allow relatively straight-forward evaluation of the ability of different array configurations to image particular source geometries. In FY-92 the code will be modified to include potential noise sources, and then used to evaluate the imaging capability of all the primary science targets for different configurations of each array.

W92-70258 **188-78-44**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
ASTROTECH 21
J. A. Cutts 818-354-4120

The objective of Astrotech 21 is to assist NASA's Astrophysics Division in formulating and implementing a long range technology plan for future Astrophysics missions. The planning process includes the definition of science objectives and observational techniques, new mission concepts and their associated technology requirements; and integrated technology planning. The Astrotech 21 technology program will be implemented by the Astrophysics division in cooperation with the Office of Aeronautics, Exploration and Technology (Code R). The work is now in transition with the initial planning phase now winding down and the implementation phase beginning. The planning activity has involved more than 1000 scientists and technologists who have participated in 11 workshops culminating in the Integrated Technology Workshops in Information Systems, Sensor Systems and Optical Systems. There has been information interchange with several subcommittees of the decadal Astronomy and Astrophysics Survey Committee (AASC), also known as the Bahcall committee, whose deliberation occurred concurrently with this first phase of the Astrotech 21. There has also been support provided to Code R planning activities and specifically in guiding the development of the Code R Integrated Technology Plan which is being prepared in response to the recommendations of the Augustine committee. A part of this activity will be to complete the initial planning activity for Information systems, Optical Systems and Sensor Systems. The first of the overguideline elements will address the initial phase of the Integrated Technology Planning for Observatory Systems. This activity had been proposed for inclusion in the Astrotech 21 planning activity in FY-91 but was deferred because of cost considerations.

W92-70259 **188-78-44**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
OPTICAL INTERFEROMETER TESTBED
M. Shao 818-354-7834
(188-78-41)

The long-term objective is to provide a comprehensive system-level ground test facility for a space-based stellar interferometer which will demonstrate the integration of controlled optics, such as optical delay lines, three-dimensional laser metrology, to monitor structural geometry and vibrations, and control structures/interactions (CSI) techniques for structural control and quieting. The goal is to verify that the integration of these technologies, as predicted by computer modeling, can produce a phase-stable space interferometer at an acceptable cost. Laser metrology is a key technology-the attainment of the astrometric goals of space-based stellar interferometers requires nanometer-level 3-dimensional metrology accuracy. The near-term objectives are the design and test of small-scale one- and three-dimensional laser metrology testbeds. These testbeds would be used to test and verify subnanometer calibration concepts which can accommodate such error sources as imperfect corner cubes, diffraction from corner-cube edges, and polarization leakage. The results from these testbeds will be incorporated into the design of the laser optical delay truss for the CSI Phase 1 testbed. The Phase 1 testbed will also incorporate laser-monitored optical delay lines as well as CSI damping technology. The metrology testbeds, working under idealized conditions, will be used as a benchmark against which to compare results from the metrology attached to the Phase 1 testbed.

W92-70260 **188-78-44**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
FUTURE GENERATION ORBITING VLBI MISSION DESIGN OPTIONS
Gerald S. Levy 818-354-0837
(689-78-25)

This RTOP will examine options and tradeoffs for Orbiting Very Long Baseline Interferometry (OVLBI) missions to follow the currently planned RADIOASTRON and VSOP spacecraft to be

launched in 1995. The studies will result in an understanding of the scientific potential of these missions and a definition of the critical technology requirements. At the advanced OVLBI workshop two distinct mission concepts were identified. The first uses one or more OVLBI satellite observatories in conjunction with ground radio astronomy observatories to produce correlated astronomical data (space-ground OVLBI). The second concept uses two or more OVLBI satellite observatories to make all their observations above the Earth's atmosphere (space-space OVLBI). The space-ground missions highest frequency will be a function of antenna technology and cost, the atmospheric propagation effect on coherence and the scientific value of the expected data. The quality of radio images formed is a function of many factors including the spacecraft orbit, and configuration as well as observation wavelength, location of the ground observatories and tracking stations. Tradeoff studies will be made to define mission scenarios and the resulting technological requirements.

W92-70261 **188-78-60**
Ames Research Center, Moffett Field, CA.
STRATOSPHERIC OBSERVATORY FOR INFRARED ASTRONOMY (SOFIA)
G. W. Thorley 415-604-5917

The objectives are to define and initiate development of the Stratospheric Observatory for Infrared Astronomy (SOFIA), to define the ground support system and to develop the operational procedures for the airborne observatory. The SOFIA is a proposed new observatory to continue NASA's airborne IR astronomy program as the successor to the Kuiper Airborne Observatory (KAO). The SOFIA features a 2.5-meter telescope mounted in a modified Boeing 747SP aircraft. Potential users of the SOFIA would make observations ranging from about 0.3 microns to 1.6 mm in wavelength. The SOFIA will provide a significant increase in scientific capability over the KAO. The approach is to continue development of the technology needed for the design and development of the SOFIA; to coordinate the results of the previous studies and the technology development, and to increase the depth of the system definition and systems analysis by completing definition studies of the aircraft system, telescope system and ground support system; to survey probable contractors and continue development of the aircraft system, the consoles and electronics system and the Federal Republic of Germany (FRG) telescope assembly; and to study acquisition and refurbishment options for a used Boeing 747SP for the SOFIA platform. The work will be performed in-house at Ames Research Center, under contract to industry, and in collaboration with the FRG.

Planetary Astronomy

W92-70262 **196-41-01**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
PLANETARY ASTRONOMY PROGRAM
J. F. Appleby 818-354-3943

This RTOP covers all RTOPS at the Jet Propulsion Laboratory (JPL) in the Planetary Astronomy Program under UPN 196. It is a consolidation of the following RTOPS: 196-20-70, 196-41-71, 196-41-73, 196-41-75, 196-41-76,196-41-77, and 196-88-00. These 22 interrelated research tasks address telescopic observations of all planetary bodies, atmospheres, and plasmas, including those of planets, satellites, the moon, asteroids, comets, rings, and circumstellar disks. This research involves groundbased and aircraft telescope observations using optical, microwave, and radar techniques covering a wide range of wavelengths from the ultraviolet to centimeter radio waves. Data are obtained as narrow and broadband spectra, photometry and images in emission, absorption, and/or reflection modes. Emphasis is on obtaining characteristic information on the composition, structure, distribution and temporal behavior of planetary objects and their various components. The basic objective of this research is to obtain observational data and to couple these data with laboratory experiments and theoretical considerations in order to determine the present characteristics and evolution of planetary objects. A major objective is to establish a database for interpretive analysis of observational results obtained by unmanned spacecraft missions to planetary objects throughout the solar system, and to define new missions and new observations to further our knowledge of the solar system, of circumstellar material, and of extrasolar planets. This RTOP also supports certain science support activities at JPL's Table Mountain Observatory Facility and JPL's Goldstone Radar Observatory, visiting distinguished scientists visits to JPL, and certain informational and educational activities.

W92-70263 **196-41-50**
Goddard Space Flight Center, Greenbelt, MD.
GROUND-BASED INFRARED ASTRONOMY
Donald E. Jennings 301-286-7701
(188-44-57; 154-50-80)

The scientific objective of this program is to obtain infrared spectra of planets with a combination of the highest possible sensitivity and the best resolution. A cryogenic postdisperser, developed at Goddard Space Flight Center, has been used with the Fourier Transform Spectrometers (FTS) at the Kitt Peak 4-meter and McMath telescopes. This narrow-band focal plane instrument improves the sensitivity of the FTS in the thermal infrared by an order of magnitude. Using this instrument on the 4-meter telescope, acetylene and ethane were observed in and out of the hot spot at Jupiter's northern latitudes. In addition, carbon-13 ethane was detected in Jupiter. With the McMath telescope carbon dioxide was observed, and hydrogen peroxide was searched for, near 8 microns. These observations were made at 0.01 cm(-1) resolution. A new spectrometer has been constructed to take advantage of the improved sensitivity available with modern detector arrays. A large cryogenic grating disperses the spectrum onto a 10x50 element array. This instrument yields another order-of-magnitude improvement in sensitivity.

W92-70264 **196-41-52**
Goddard Space Flight Center, Greenbelt, MD.
IMAGING STUDIES OF COMETS
Malcolm B. Niedner, Jr. 301-286-5821

This RTOP provides for the operation of a small high altitude observatory, the Joint Observatory for Cometary Research (JOCR). The imaging data obtained at JOCR are both wide- and narrow-field, and principally address the interaction of comets with solar radiation and wind. Research is most effective when in situ solar wind and Interplanetary Magnetic Field (IMF) data from spacecraft are available to compare with the imagery. Funding under this RTOP provides support for the operation of the observatory only. However, analysis of research results is funded by the interested program office. The observatory site in central New Mexico is one of the darkest sites left in the continental U.S. Wide-field photography (using the comet Schmidt camera) of more than 12 comets since 1973, including recent comets IRAS-Araki-Alcock, Giacobini-Zinner, Halley, and Bradfield, has been carried out. Analysis of some of the imagery has provided information on the interaction of comets with high-speed solar-wind streams and magnetic sector boundaries, the magnetic field strength in the tail, the injection speed of ions into the tail, pressure balance conditions across the tail, and other phenomena.

W92-70265 **196-41-54**
Goddard Space Flight Center, Greenbelt, MD.
ADVANCED INFRARED ASTRONOMY
Michael J. Mumma 301-286-6994

The molecular constituents of planetary atmospheres and comets, and processes occurring in them, are studied through observations of their IR line spectra. High spectral and spatial resolution are utilized in order to obtain information on compositions (e.g., of cometary nuclei), structure (e.g. temperature profiles), spatially localized phenomena (e.g., hot spots) and dynamical

processes (e.g., winds in planetary atmospheres). Models for predicting and interpreting planetary and cometary spectra are developed. Observations are conducted from ground-based observatories and from the Kuiper Airborne Observatory (KAO). In Task 01, laser heterodyne spectrometers are used for ultrahigh spectral and spatial resolution in the mid-infrared (8 to 30 micron). In Task 03, comets are investigated with grating and Fourier transform spectrometers at near infrared (1 lambda less than 8 microns) wavelengths. Task 02 has two objectives. The first is directed towards extending our knowledge to planetary systems which may exist around other solar-type stars. The underlying principle is that such extra-solar planetary systems could be detected by measuring the small Doppler reflex which planetary orbital motion produces in the spectrum of the parent stars. The objective of this task is to validate such an approach by measuring the velocity stability of integrated sunlight with Fourier transform and heterodyne spectrometers. Solar-cycle related effects which are observed are compared to the 13 meter/sec Doppler reflex induced by the orbit of Jupiter. Prescriptions are developed for separating these effects so that planetary Doppler signatures can be identified in stellar spectra. Another objective is to investigate global scale thermal wave phenomena in the atmospheres of the giant planets, and to characterize these in terms of atmospheric processes or internal seismological signatures.

W92-70266 **196-41-67**
Ames Research Center, Moffett Field, CA.
VOLATILES IN THE SOLAR SYSTEM
D. P. Cruikshank 415-604-4244

The objective is to obtain and analyze spectroscopic data on the surfaces and atmospheres of the volatile-rich bodies (planets, satellites, asteroids, and comets) in the outer Solar System. Such information is needed to interpret spacecraft observations of the planets and satellites already made and those planned for future NASA missions to the outer Solar System. An additional objective is to organize and conduct a workshop on the presence and nature of organic matter in comets in connection with NASA's plans for space missions to the comets (the Comet Rendezvous Asteroid Flyby, and Comet Nucleus Sample Return missions). A further objective is to promote communication of Ames Research Center scientists with scientists from other institutions. The approach is to obtain astronomical observations of the planets and other bodies in the Solar System with the telescopes at Mauna Kea Observatory, notably the NASA Infrared Telescope Facility, and to analyze these data using standard techniques and the body of laboratory data available for comparison. The need for additional laboratory data will be identified as appropriate. The approach related to the workshop on cometary organics consists of the identification of speakers and appropriate topics, issuance of invitations, and then the conduct of the workshop, followed by the preparation of an appropriate publication of the materials presented.

W92-70267 **196-88-01**
Ames Research Center, Moffett Field, CA.
IMPACT CATASTROPHISM ON THE TERRESTRIAL PLANETS
G. C. Carle 415-604-5765

The objective of this RTOP is to develop an understanding of the effects of catastrophic impacts on planetary bodies and their processes during the span of geologic history. The approach of the RTOP is to study the effect of impacts on planetary bodies in order to evaluate the role impacts played in shaping the biota and geologic evolution of the terrestrial planets. It is apparent that what is first needed is a complete theory for the probability of occurrence of rare catastrophic impacts. By developing such a theory, we can begin to address important questions concerning a variety of geochemical and biologic questions involving the early history of the terrestrial planets.

W92-70268 **196-88-50**
Goddard Space Flight Center, Greenbelt, MD.
PLANETARY ASTRONOMY
Jacob I. Trombka 301-286-5941

Gamma-ray and x-ray detectors are significantly affected by the space radiation environment. The objective is to study these effects in detector systems that are being proposed for planetary space flight missions. Programs for predicting induced activity have been developed and will be compared with experimental measurements. These measurements will be carried out utilizing balloon flights and high energy accelerators. Radiation damage effects can be annealed out during space flight. Methods for annealing detectors will be studied using Mars Observer prototype detectors.

Life Sciences SR&T

W92-70269 **199-02-31**
Lyndon B. Johnson Space Center, Houston, TX.
CLINICAL MEDICINE TECHNOLOGY WATCH
C. W. Lloyd 713-483-7894

Development of instrumentation technologies and protocols for Space Medicine Programs as an on-going task is required as the Allied Health Professions evolve. During lunar/Mars missions, immediate return to Earth will not be possible; therefore, appropriate medical care capabilities will have to be an integral part of these programs. Current Space Station Freedom (SSF) mission scenarios describe up to one 180 day mission for a crew of four people. For the SSF Program, the Medical Sciences Division is developing a modular in-flight Crew Health Care System (CHeCS), which is comprised of three components: Health Maintenance Facility (HMF) which will provide the in-flight medical capabilities, the Exercise Countermeasures Facility (ECF) which will provide the capabilities to counteract musculoskeletal and cardiovascular deconditioning, and the Environmental Health System (EHS) which will be responsible for the monitoring of the quality of the SSF internal environment. The specific objectives of CHeCS are outlined in JSC 31013. The unique challenge of providing medical capabilities for SSF and future Space Medicine Programs will continue to require development of low weight, low volume, highly automated medical care based as much as possible on terrestrial medical tenets and equipment.

W92-70270 **199-02-31**
Lyndon B. Johnson Space Center, Houston, TX.
LONGITUDINAL STUDIES (MEDICAL OPERATIONS LONGITUDINAL STUDIES)
Larry J. Pepper 713-483-7999

The objective is to conduct longitudinal retrospective and prospective studies of medical data from astronauts, a control group of civil servants, and other civil service employees. The study involves individuals in a relatively closed population in an attempt to relate changes in physiological and/or pathological systems to specific factors associated with individual traits of the astronauts and associated occupational exposure. Study areas of particular interest consist of: long-term adaptation mechanisms to weightlessness; changes observed in annual medical certification and periodic examinations; changes in lifestyle variables; and the effects of the occupational exposure associated with their unique occupation. Effects of the above mentioned factors on the normal aging process and disease incidence is of particular interest. The approach includes: (1) inputting and storing all astronaut medical exams (flight, annual, periodic illness) in a relational computer database; (2) collecting and storing similar information on a control group of civil servants (matched on age, sex, body size, and smoking history) and other civil servants; (3) analyzing the longitudinal information comparing these groups; (4) evaluating cumulatively the pre/postflight physiological changes across missions; and (5) reviewing periodically to include new parameters.

W92-70271 **199-04-11**
Lyndon B. Johnson Space Center, Houston, TX.
ENVIRONMENTAL HEALTH
J. M. Waligora 713-483-7200

The objectives of the Environmental Health RTOP are to support: (1) research involving specification, measurement, and control of the man-made internal environment in the manned spacecraft and habitats; (2) research and technology assessment essential for the definition, development, and updating of the Space Station Environmental Health Subsystem; and (3) research to study the response of the body to deleterious levels of environmental factors that may be encountered in flight, to allow prediction of physiologic or pathologic response, and to prevent or ameliorate this response. The approach utilized to accomplish these objectives will be to sponsor in-house and outside studies which are needed to define requirements for environmental health factors, and acceptability limits; to provide the technology to detect compliance with these requirements; and finally, to define the mechanism of response of the body to deleterious environmental factors and investigate potential countermeasures.

W92-70272 **199-06-11**
Lyndon B. Johnson Space Center, Houston, TX.
BEHAVIOR AND PERFORMANCE RESEARCH
Albert W. Holland 713-483-8482
(199-22-06; 199-06-12)

This RTOP addresses the human behavior and performance issues inherent in extended-duration space missions. As space missions increase in duration and complexity, issues such as individual adaptation to extended confinement, performance of isolated teams, cognitive readiness, motivation maintenance, and psychophysiology become salient. The RTOP focuses upon individual and team selection and training, as well as improved mission design, as principal strategies for maintaining and enhancing crew psychological health, safety, and performance. The approach is to conduct applied behavioral research whose results can be rapidly and effectively utilized by space operations to resolve salient human issues. The RTOP objectives are to: (1) determine the critical factors which affect behavior and performance in spaceflight and understand the underlying mechanisms; (2) develop methods of mission and risk analysis which characterize mission-specific demands on health and performance; (3) develop and verify procedures and strategies for assessing, maintaining, and enhancing crew health and performance; (4) utilize mission testbeds and field analogs as appropriate to maintain a knowledge base consistent with the requirements of NASA Space Programs; and (5) generate program-specific deliverables such as guidelines and standards in crew training, selection, and mission operations.

W92-70273 **199-14-11**
Lyndon B. Johnson Space Center, Houston, TX.
CARDIOPULMONARY RESEARCH
S. M. Fortney 713-483-7213

The overall objective is an understanding of the cardiovascular changes which occur with space flight and their impact on crew members. The specific aims are to: (1) define the underlying mechanisms of cardiovascular deconditioning; (2) provide appropriate countermeasures for these effects; (3) assess the occurrence and consequences of cardiac arrythmias during spaceflight; (4) assess the validity of ground-based and animal models to spaceflight; and (5) provide basic scientific support for operational programs such as the Extended Duration Orbiter (EDO), Space Station Freedom (SSF), or the Space Exploration Initiative (SEI). Ground-based studies on both human and animal subjects will in part utilize: (1) provocative techniques such as lower body negative pressure and exercise testing; (2) bedrest studies as analogs to weightlessness; (3) noninvasive and invasive cardiovascular monitoring; and (4) mechanical and pharmacologic interventions, all in an effort to accomplish the goals set forth above.

W92-70274 **199-14-12**
Ames Research Center, Moffett Field, CA.
CARDIOPULMONARY PHYSIOLOGY
A. R. Hargens 415-604-5746

The overall objective is to develop an understanding of the cardiopulmonary and fluid-electrolyte changes occurring with spaceflight. Specific aims are to: (1) define underlying mechanisms; (2) determine whether specific cardiovascular risks occur with short- and long-term microgravity exposure; (3) develop and test appropriate models and countermeasures to prevent or treat cardiopulmonary deconditioning; and (4) develop and implement appropriate spaceflight experiments. The approach in accomplishing these objectives will involve ground-based studies on both human and animal subjects. Specific activities will include: (1) determining effects of exercise countermeasure on deconditioning; (2) exposing of humans to horizontal and head-down bedrest and water immersion to study mechanisms of deconditioning; and (3) testing procedures, devices and drugs to prevent and counteract deconditioning. Results should lead to: (1) a better understanding of mechanisms of cardiopulmonary deconditioning; (2) better devices and procedures for modifying deconditioning effects; and (3) specific spaceflight experiments. Results of proposed studies will improve flight safety and understanding of spaceflight risks. This research will also provide access to flight for a broader segment of the population and will use microgravity to expand understanding of cardiopulmonary/fluid-electrolyte function and autonomic nervous system control of the cardiopulmonary system.

W92-70275 **199-16-11**
Lyndon B. Johnson Space Center, Houston, TX.
NEUROSCIENCE
D. L. Harm 713-483-7222
(199-16-12)

The overall goals of this RTOP are: (1) to understand how the central nervous system (CNS) processes sensory, motor, and sensorimotor information in microgravity and how this leads to the total space adaptation syndrome; (2) to determine how the individual readapts to a normal 1-g environment, particularly following long duration spaceflight; and (3) to develop, implement, and evaluate countermeasures to minimize SMS, orientation disturbances, and performance decrements during adaptation to microgravity and readaptation to 1-g. The approach will be to conduct an integrated set of in-house and extramural investigations designed to address the above goals. The investigations will include ground-based studies that are operationally oriented as well as those of a basic science nature, and space flight studies. In addition, findings from the Extended Duration Orbiter (EDO) Medical Project and EDO related investigations will be applied where appropriate to proposed RTOP investigations. The primary areas of focus will be central processing of sensory information, sensory, and sensorimotor contributions to eye-head-hand coordination/control mechanisms, posture and locomotion control, spatial orientation processes, perceptual responses and motion sickness, sensory and sensorimotor adaptation/readaptation processes, and development and evaluation of countermeasures for disturbances in these processes. Human subjects will be primarily used. New facilities, hardware, and measurement procedures will be developed as required.

W92-70276 **199-16-12**
Ames Research Center, Moffett Field, CA.
NEUROSCIENCE (BIOMEDICAL)
N. G. Daunton 415-604-4818

Significant changes occur in the way the Central Nervous System (CNS) processes sensory inputs and motor outputs during adaptation to the environment of space and, following extended micro-g exposure, to the 1-G environment of Earth or partial-G environments of planetary surfaces or rotating space stations. These changes lead to deficits in perception, performance, locomotion and postural control, and spatial orientation, and also to space motion sickness, all of which can impair the operational efficiency, health, and safety of astronauts during missions and

on return to Earth. It is not known whether the changes in CNS structure and physiology that underlie these deficits will be reversible after years of exposure to micro-G. The overall objective of this RTOP is to identify CNS components and mechanisms underlying the process of neural adaptation to different gravitational environments, so that the consequences to the CNS of long-term, as well as short-term exposures can be determined. The general approach used involves identifying in ground-based (including simulated micro-G and hyper-G) and flight (micro-G) experiments the functional (behavioral and performance) changes that occur in sensory-motor systems (e.g., vestibular and neuromuscular) during adaptation to altered-G. Then, experiments are designed to determine the neurophysiological, neurochemical, and structural changes in the CNS that underlie these changes. With this knowledge, behavioral and/or neuropharmacological countermeasures can be developed to minimize specific functional deficits.

W92-70277 **199-18-12**
Ames Research Center, Moffett Field, CA.
REGULATORY PHYSIOLOGY (BIOMEDICAL)
J. Vernikos 415-604-3736
(199-14-12; 199-16-12)

The objective is to determine the integrative mechanisms regulating physiological adaptation to space. The consequences to crew health and performance of the physiological adaptation to spaceflight and its effect on other homeostatic systems will be investigated measuring responsiveness to spaceflight events as well as to reference standardized stimuli. To accomplish this objective, ground-based simulation research designed to investigate operational factors and basic mechanisms will be conducted. All research will be conducted in man as much as possible and will include animal studies where necessary. The physiological responses induced by spaceflight will be simulated using immersion, horizontal, or head-down bedrest. Specific activities will include: (1) the understanding of the mechanisms and development of countermeasure options for the impaired thermoregulation in deconditioned subjects during exercise; and (2) the effect of the altered/adapted physiological baseline on the body's endocrine responding systems, and on the ability of crews to respond to physical, emotional, and operational stresses and to perform. Results will improve flight and extravehicular activity (EVA) safety, contribute to EVA suit technology requirements, and improve health and psychosocial stability during extended spaceflight by developing safer and more effective countermeasure options.

W92-70278 **199-26-11**
Lyndon B. Johnson Space Center, Houston, TX.
BONE MINERAL METABOLISM AND MUSCLE PHYSIOLOGY
M. Jaweed 813-483-7269
(199-18-11; 199-14-11)

The overall goal of the RTOP is to understand the physiological changes in musculoskeletal system of astronauts, occurring due to long-term exposure to microgravity. The research effort is directed towards elucidating the pathogenesis associated with muscle atrophy and bone demineralization and to develop safe and effective physical, physiological, nutritional pharmacological, and biomechanical countermeasures to maintain the musculoskeletal integrity and function. This research is also focused to trace the course of bone and muscle recovery after astronauts' return to the 1-g environment, so as to afford protection against the potential hazards of osteoporosis and muscle injury. Overall, this research program is geared to maintain functional capacity of the astronauts and to develop safeguards against potential hazards both in 0-g and 1-g environment. The program entails a comprehensive evaluation of bone demineralization and muscle atrophy and their prevention at the level of organism, organ, tissue, and cell. Primarily, non-invasive or semi-invasive biochemical, histochemical, physiological, nuclear magnetic resonance (NMR) tissue culture, and radiological methods would be employed to define the loss of mass and function, decreased vascularity, altered regeneration and increased vulnerability to damage. The studies will be conducted with the Space Transportation System (STS), LMEI and MTCC astronauts, bed rest, dry immersia, cast-immobilized or spinal cord injured subjects and experimental animals. Both the field centers and acedemic institutions will partake in the program.

W92-70279 **199-26-12**
Ames Research Center, Moffett Field, CA.
MUSCULOSKELETAL (BIOMEDICAL)
R. E. Grindeland 415-604-5756
(199-40-42)

The long-range goal is to understand the process of musculoskeletal weakness and wasting in space in order to reduce or prevent its occurrence by rational countermeasures. The fundamental concern for tissues designed to support weight is a reduced function in space and injury on return to earth's gravity. Specific goals are directed toward characterizing the time course, morphology, biochemistry, biomechanics, and physiology of the adaptation of support structures to changes in simulated weightlessness. The focus is entirely on bone, muscle, and connecting ligaments and tendons. However, there is necessarily an overlap with other biomedical areas, especially cardiovascular, endocrine, and neurai because of the functional interdependence of support structures with these systems. Inherent in efforts to understand the changes that occur with disuse are the development and validation of methods to monitor the process. A basic science approach is primarily used since the most effective methods for preventing and treating muscle and connective tissue atrophy, as well as bone demineralization, will be derived from a knowledge of their mechanisms. Experimental models are designed to disrupt, and/or evaluate the support function of the musculoskeletal system in whole animals or tissues. A detailed mechanistic approach, combining animal and human research, is used. Studies are coordinated with flight projects to validate the models for the zero gravity environment. Current preventive measures included in this research are exercise, centrifugation, nutrition, and pharmacologic agents.

W92-70280 **199-26-14**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
MUSCULOSKELETAL
R. H. Selzer 818-354-5754

The objective of this task is to develop and validate methods to measure muscle volume change associated with disuse. A technique is currently under development to measure lower leg muscle volume from magnetic resonance images. This technique is designed for use in bedrest studies, as a tool to evaluate muscle atrophy countermeasures or for pre- and post-flight monitoring of muscle. An ultrasound technique for measurement of muscle volume is also under investigation and initial tests support the feasibility of this approach. The method utilizes a magnetic spatial locator device to track the position of the ultrasound imaging probe as it is applied to various positions along the length of a muscle. Computer image processing methods are used to reconstruct the volume of the entire muscle. An ultrasound scanner, spatial locator, and small computer are to be assembled as a self-contained portable ultrasound muscle measurement system. The two approaches to muscle volume assessment complement one another in the sense that magnetic resonance imaging (MRI) has the potential for very accurate volume measurements and can be used to validate the ultrasound technique. The ultrasound method in turn, will be portable and has potential for in-flight use.

W92-70281 **199-30-62**
Ames Research Center, Moffett Field, CA.
BIOGEOCHEMICAL RESEARCH IN TROPICAL ECOSYSTEMS
P. A. Matson 415-604-6884
(199-30-72; 463-61-02)

The objective of this research is to quantify fluxes of important biogenic gases from tropical ecosystems, and to understand the sources, sinks, and processes that control flux out of the systems. The long-term goal of this project is to establish a geographic perspective on trace gas flux and biogeochemical processes in tropical environments. This encompasses measurement of gas

fluxes from soil and vegetation and estimation of their regional and global budgets. The approach is to measure emissions of nitrous oxide, nitric oxide, methane, carbon dioxide, and other gases in a range of ecosystems representing gradients of climate, fertility, and disturbance. Studies along such gradients will improve understanding of the factors that control flux, and will provide the basis for developing models that predict flux. Such models, driven by variables such as land use type, climate-moisture characteristics, and canopy characteristics, will be tied to remote sensing techniques for extrapolation to regional and global scales.

W92-70282 **199-40-12**
Ames Research Center, Moffett Field, CA.
NEUROSCIENCE (INFORMATION PROCESSING)
M. D. Ross 415-604-5757
(199-40-22; 199-40-42)

The long-term goals of this research are: (1) to understand information processing in animal linear bioaccelerometers, on Earth and in space, through experimental research and computer-assisted reconstruction and modeling; and (2) to learn whether gravity interacts with the genome to produce the endorgan organization present in the adult. The RTOP represents a coordinated approach to research on mechanisms underlying transduction, on the morphological organization of the macular neural network and its evolution, on physiological characteristics of vestibular nerve responses, and on the development of the gravity-sensing endorgans. The findings of the past few years are now being utilized in modeling efforts that rely greatly on use of computer technologies. The approaches to achieving the goals listed above place heavy emphasis on experimental study in combination with computer-assisted reconstruction and modeling. Mathematical approaches are becoming increasingly important. Models generated can be used to predict changes likely to occur in space and will be tested at a future date through highly focused, rigorous experiments in the space environment. Studies of both developing and adult animals in space will be required to satisfactorily answer questions concerning the role of gravity in shaping the mature system and to increase our understanding of macular (and neural) adaptation to altered gravity.

W92-70283 **199-40-62**
Ames Research Center, Moffett Field, CA.
FLIGHT RESEARCH
R. W. Ballard 415-604-6748

The objectives of this RTOP are to support research directly related to an accepted flight experiment and to support scientific studies to improve existing flight hardware.

W92-70284 **199-52-11**
Lyndon B. Johnson Space Center, Houston, TX.
CHARACTERISTICS OF VOLATILES IN INTERPLANETARY DUST PARTICLES
Everett K. Gibson, Jr. 713-483-6224

The goal of this study is to investigate the elemental and molecular compositions of volatiles present in interplanetary dust particles (IDPs). Interplanetary dust is important to studies of the origin of the solar system because it is the material from comets and asteroids - the smallest surviving bodies from the early solar system. The investigation will obtain compositional information about the volatiles present at the time of formation of these primitive particles. Because of the possibility that the dust particles may have a cometary origin, their analysis could provide information about the volatiles associated with the dusty component present in comets. Exobiological interest in cosmic or interplanetary dust particles stems from their potential for contributing to the elucidation of the cosmic history of the organogenic elements (i.e., H, C, N, O, S, and P) that make up all living systems. Therefore, the study of IDPs will enhance our understanding of comets, asteroids, primitive meteorites, and the solar system along with providing an increased knowledge of the interstellar medium.

W92-70285 **199-52-12**
Ames Research Center, Moffett Field, CA.
COSMIC EVOLUTION OF BIOGENIC COMPOUNDS
T. Bunch 415-604-5909
(199-52-22; 199-52-32; 199-50-42)

The objective of this RTOP is to understand the history of biogenic elements (C, H, N, O, P, S) and their compounds in the galaxy and the early solar system. The following lines of inquiry are pursued: (1) trace the physical and chemical pathways taken by the biogenic elements and their compounds from their origins in stars to their incorporation in the pre-planetary bodies; (2) determine the kinds of measurements that can be made on the biogenic elements and compounds in the galaxy and solar system in order to develop theories about the formation of the solar system and the prebiotic evolution and origin of life; and (3) determine the ways in which the physical and chemical properties of the biogenic elements and compounds may have influenced the course of events during the formation of the solar system and the component bodies. The approaches of the RTOP are to: (1) characterize plausible chemical reaction pathways for candidate interstellar organic species by quantum chemistry methods; (2) obtain laboratory infrared spectra of artificial molecular mixtures for comparison with astrophysical observations; (3) analyze U-2 aircraft-collected interplanetary dust particles for biogenic and inorganic elements and characterize their phase structures; and (4) determine exobiology requirements for new telescope capabilities and recommend observation priorities.

W92-70286 **199-52-26**
Langley Research Center, Hampton, VA.
PHOTOCHEMISTRY/GEOCHEMISTRY OF THE EARLY EARTH
Joel S. Levine 804-864-5692

The objectives of this RTOP are to develop a better understanding of the geochemical and photochemical processes that controlled the composition of the atmosphere over geological time. The approach consists of: (1) the development and application of a geochemical flux model to investigate the transfer of carbon, nitrogen, oxygen, hydrogen, sulfur, and chlorine species between the atmosphere, oceans, solid Earth, and biosphere over geological time; (2) photochemical calculations of the composition of the early atmosphere and its evolution over geological time; (3) studies of the geochemistry, geology, and atmospheric chemistry of early Mars to better understand the early Earth, to assess the possibility of life on Mars, and to provide scientific support to NASA's Manned Mars Mission planning activities; and (4) to assess the feasibility of terraforming Mars to make it more Earthlike.

W92-70287 **199-52-32**
Ames Research Center, Moffett Field, CA.
THE EARLY EVOLUTION OF LIFE
D. J. DesMarais 415-604-3220
(199-52-22; 199-52-82)

The objective of this RTOP is to understand the nature and evolution of primitive organisms and to relate such evolution to those forces which guided the evolution of the planet. The approach of the RTOP will be to explore the mechanisms, processes and environments associated with the early evolution of life on Earth as an approach to understanding life elsewhere in the Universe. Two repositories of evolutionary information are examined: the molecular record in living organisms and the geologic record in rocks. Biological studies address the early evolution of the complex systems that constitute the essential attributes of life. Energy transduction is being studied by examining the Archaebacteria (e.g., extreme halophiles, acidophilic thermophiles) and comparing their properties with those of eubacteria. The development of oxygen-requiring pathways in lipid synthesis is investigated both in eubacteria and in Eukaryotes. Geologic studies seek to elucidate earlier biochemistries through analyses of ancient biological material preserved in stromatolitic rocks. The paleoenvironment (e.g., its structural setting and the chemical composition of its ocean and atmosphere) is also being described.

W92-70288 **199-52-54**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
EXOBIOLOGY INTACT CAPTURE TECHNOLOGY DEVELOPMENT
P. Tsou 818-354-8094

The ultimate objective of our endeavor is to return to Earth intact particles for detailed laboratory analyses. Unlike destructive dust capture techniques, intact capture can preserve the chemistry, biogenic elements, and petrology of the captured particles. In 1988, EXOICE, a successful proposal to the Space Station Attached Payload AO made use of one level of the passive intact capture technology that was laboratory-proven at the time of the proposal submission. In this plan, supportive activities toward the overall development of this technology shall be pursued with an emphasis toward the documentation of achievements thus far.

W92-70289 **199-55-12**
Ames Research Center, Moffett Field, CA.
ADVANCED PROGRAMS IN BIOLOGICAL SYSTEMS RESEARCH
R. D. MacElroy 415-604-5573
(199-52-22; 199-61-12; 199-30-32)

The objectives of the RTOP are two-fold: (1) to understand the relationship between the causes and effects associated with changes in biological systems ensuing from natural or artificial changes in their environment, in the past, present, and future. The focus here is on conducting research and analysis tasks that are multi-disciplinary, that establish interfaces between Exobiology, Biospherics, Controlled Ecological Life Support System (CELSS) and Search for Extraterrestrial Intelligence Research Programs and that begin laying the ground work for advanced missions; and (2) to identify, determine the feasibility of, and develop programmatic approaches to implement new areas of investigation within the overall context of Biological Systems Research. The approaches of this RTOP are: (1) to determine the basis for the origin and development of interactions between organisms and their environment in both natural and artificial ecosystems; (2) to develop methods for characterizing the state and dynamical interactions of biological systems in and with their environment; (3) assess the requirements for and feasibility of creating habitable extraterrestrial environments; and (4) to assess the impact of evidence of life elsewhere in the universe on human decisions to establish extraterrestrial habitats.

W92-70290 **199-61-11**
Lyndon B. Johnson Space Center, Houston, TX.
REGENERATIVE LIFE SUPPORT SYSTEMS PROGRAM
D. L. Henninger 713-483-5034

Future NASA mission scenarios to explore the solar system are by nature long-duration missions and could last years at a time. Human life support systems must operate with very high reliability for long periods with minimum resupply. These life support systems will make use of higher plants, microorganisms, and physicochemical processes for the production of water, food, and oxygen while converting carbon dioxide and processing waste materials. Development of a regenerative life support system (or a Controlled Ecological Life Support System (CELSS)) will be a pivotal capability for missions to the moon and Mars. Research within the CELSS Program has been going on for several years, and much more basic and applied research must be conducted. In addition, development of a CELSS must begin to move into the area of technology development. The CELSS Breadboard Project was the first step designed to look primarily at plant production under controlled conditions. Development of test bed facilities must be continued for assembly of all the components and subsystems, both physicochemical and biological, in order to look at the interactions of various components and to examine system parameters. Efforts must continue to complete definition of requirements for a human-rated test bed facility to begin conceptual design of such a facility. This RTOP is to continue and initiate new life support research and development and to continue development of test bed facilities. Seven tasks are described as follows: (1) waste processing for a CELSS; (2) human-rated CELSS test bed facility conceptual design; (3) CELSS modeling and analysis; (4) CELSS test bed development and operations; (5) systems analysis of CELSS monitoring and control strategies; (6) lunar regolith as a soil for plant growth; and (7) CELSS zeoponics research.

W92-70291 **199-61-12**
Ames Research Center, Moffett Field, CA.
BIOREGENERATIVE LIFE SUPPORT RESEARCH (CELSS)
R. D. MacElroy 415-604-5573
(199-61-23)

The objective of this RTOP is to support the scientific experiments, the technological investigations, and potential flight experiments necessary for the development of bioregenerative life support systems. Investigations are directed toward the practical use of the functions performed by higher plants, algae, microorganisms, physical-chemical processes and mechanical devices for human life support. Of particular interest are the functions that produce potable water, food and oxygen, absorb carbon dioxide and process waste materials in orbit or on planetary surfaces. The goal is to ensure recycling materials by regeneration of consummables needed for crew support. Included also are studies of the control and the efficiency of such bioregenerative systems. The approach involves study of the rates at which organisms or physical-chemical devices produce or consume biomass, food, oxygen, carbon dioxide, potable water, and fixed nitrogen in response to changes in environmental variables such as temperature, atmospheric gas composition, light (intensity, duration, and quality), humidity, wind speed, and the composition of nutrient medium. These investigations are also conducted to improve the methods available for increasing system efficiency, stability and control through automated sensing, data collection, and data interpretation. The data collected form a science-requirements base for the use of the Controlled Ecological Life Support Systems (CELSS) Projects and the design of experiments to be conducted in space.

W92-70292 **199-61-14**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
EVALUATION AND DESIGN OF FERMENTERS FOR MICROGRAVITY OPERATION
G. R. Petersen 818-354-7019

The objectives of this RTOP are to use sound engineering and scientific approaches to design and build an operational bioreactor system(s) for eventual testing under microgravity conditions (STS missions); obtain operational data on such bioreactor systems as well as on the effect of microgravity on cultured microorganisms; and use ground based experimental analyses of such bioreactor systems to develop flight ready instrumentation. Meeting the needs of microbial and biological processing in microgravity requires development of both production model reactors and research scale reactors. Development of a microbial biomass/production model reactor has been the main focus of this effort and ground based models have been built and tested. These phase separated membrane bioreactor (PSMB) models are being examined for configuration, material requirements and operational requirements. Upon completion of this work the data will be used to design and build an actual piece of flight hardware. A research reactor which can be used to examine microgravity effects has not yet been completely designed although several possible models have been proposed. Reactor design(s) must be able to permit examination of: (1) cell biology effects such as DNA replication, cell division, morphology; (2) intracellular metabolic effects; and (3) microbial ecological effects such as the intercellular metabolic dependencies found in heterogeneous microbial populations. If resources and time permit, designs for generic reactor configurations which are adaptable for special growth requirements for examining microgravity effects will be examined. Designs for ground based models to test concepts will be followed by the construction and testing of such models. This basic engineering data will permit trade-off analyses.

Balloon Program

W92-70293 **353-87-02**
Goddard Space Flight Center, Greenbelt, MD.
BERYLLIUM TO SILICON ISOTOPES USING AN ADVANCED MAGNET SPECTROMETER
Robert E. Streitmatter 301-286-5481

This RTOP is to support efforts in the design of a magnet spectrometer capable of measuring isotopic composition in the cosmic radiation. The design goal is measurement of isotopes of beryllium through silicon in the energy range from 160 to 1400 MeV/nucleon. Data from such a spectrometer would be a significant addition to the existing particle astrophysics dataset. In particular, this work is aimed at optimization of a time-of-flight system and Cherenkov detector to be used in a magnet spectrometer utilizing the NASA/Balloon Borne Magnet Facility.

W92-70294 **353-87-02**
Marshall Space Flight Center, Huntsville, AL.
MEASUREMENT OF ENERGY SPECTRA OF COSMIC RAYS FROM 20 TO 1000 GEV PER NUCLEON
T. A. Parnell 205-544-7690

After completing the development of the Bristol University Gas Spectrometer Four (BUGS-4), a balloon-borne measurement of the cosmic ray composition (oxygen through iron) and spectra between 20 and 1000 GeV/nucleon will be performed. The instrument uses two Cerenkov counters in spherical shell (radius 1.4 meters) diffusion boxes to measure the primary charge. A spherical gas-filled detector in the center measures impact parameter (trajectory information and energy to approximately 1000 GeV/nucleon). This is accomplished by separating prompt gas scintillation and Cerenkov signals and by measuring the time of arrival and pulse height of a drift pulse. The instrument is mechanically complete, including the Cerenkov radiators and photomultiplier tube assemblies. The instrument will be shipped to Huntsville, AL and refurbished, including replacing components if necessary. Flight electronics and ground support equipment will be designed and developed. The instrument will be calibrated and a balloon-borne observation will be made, followed by analysis of the data. This is a joint project between NASA/MSFC, the University of Alabama in Huntsville, and Bristol University, England.

Solar Terrestrial Mission Operations and Data Analysis

W92-70295 **370-09-00**
Goddard Space Flight Center, Greenbelt, MD.
ARCHIVAL TASK FOR THE EQUATORIAL SAN MARCO D AND AE SATELLITE MISSIONS
R. A. Hoffman 301-286-7386

The objective is to archive on well documented optical disks the reduced experimental data from the San Marco D and AE satellites. The bulk of this RTOP will be devoted to reducing data from the San Marco EFI, IVI and WATI experiments to an agreed-upon common data rate and then merging these files, together with data supplied by the European San Marco experimenters, onto a set of National Space Science Data Center (NSSDC) approved optical disks. The merging will be done at the University of Texas via a GSFC grant from these funds. A secondary task will be the clean-up of the final files of the AE data base. These later efforts have been in progress for some time and should finish in early 1992.

Astrophysics Mission Operations and Data Analysis

W92-70296 **399-18-00**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
HIPPARCOS VLBI
R. A. Preston 818-354-6895

The ESA satellite Hipparcos will determine the positions, proper motions, and trigonometric parallaxes of 100,000 optical stars with unprecedented accuracy. The Hipparcos observations will be tied to the Jet Propulsion Laboratory (JPL) Very Long Baseline Interferometry (VLBI) celestial reference frame, which is composed of the radio cores of distant quasars and galaxies. This will allow Hipparcos studies of stellar and galactic dynamics to be linked to a nearly inertial reference frame, and will result in a common optical/radio high precision celestial reference frame. The Hipparcos and VLBI reference frames will be tied together by radio stars which can be positioned directly in both frames. In the last year, an astrometric VLBI observational program was continued on 12 radio stars, mostly of the RCSVn class of close binaries (approximately 0.001 second separation), using phase-reference techniques. Previous observations have also provided significant new information on stellar radio emission mechanisms.

W92-70297 **399-20-00**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
THE NASA/IPAC EXTRAGALACTIC DATABASE (NED)
G. Helou 818-584-2928

The purpose of the NASA/IPAC (Infrared Processing and Analysis Center) Extragalactic Database (NED) is to provide an on-line database service for supporting extragalactic research. The database will contain up-to-date references to the literature, abstracts from the major journals, and a master directory of objects, their names and cross-identifications. Astronomical data on these objects will be collected from the literature and entered into the database. A convenient, user-friendly interface is a requirement for efficient use of the database. The database and interface are set up and maintained on the IPAC computers, and made available by remote access over the network to the astronomical community at no cost to the user. These services are also accessible world-wide.

W92-70298 **399-20-01**
Ames Research Center, Moffett Field, CA.
CENTER FOR STAR FORMATION STUDIES
D. J. Hollenbach 415-604-4164

One objective of this RTOP is unified theoretical analysis of the problem of star formation. Solid achievement is likely to come, however, only with a healthy awareness of constraints placed on theoretical ideas by the ever increasing data base. Second, the evolution of dust in the interstellar medium is theoretically studied. The approach of this RTOP is to show that the interrelated theoretical problems cannot be attacked in isolation, but must be approached from the viewpoint of overall consistency with advances in other fields. Comprehensive investigation includes studies of patterns of star-forming regions on galaxy wide scales; dynamics, structure, energetics, and chemistry of the interstellar medium; details of the fragmentation of molecular clouds and gravitational collapse of their dense rotating cores; possible differences in the formation of high and low mass stars; formation and evolution of protostars and nebular disks; mechanisms of planetary system formation and disk dispersal; the origin of bipolar flows and their effect on the surrounding gas and dust; the effect of the radiation from young stars on circumstellar material; the origin of water masers and Herbig-Haro objects associated with star-forming regions; the influence of strong shock waves on the abundance, composition and the distribution of interstellar dust; the role of circumstellar polycyclic aromatic hydrocarbons (PAHs) in the formation of C-stardust; and the formation of interstellar icy grain mantles.

W92-70299 **399-30-00**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
IPAC ASTROPHYSICS DATA SYSTEM (ADS) SUPPORT
J. C. Good 818-584-2939

The IPAC (Infrared Processing and Analysis Center) support of the Astrophysics Data System (ADS) Project involves project management; and integration, administration, and operation of the ADS system. IPAC is the administrative center for ADS. As such, it provides not only project management, but also logistical and consulting support to other ADS nodes and to users. In addition, overall systems integration oversight is provided by IPAC personnel. IPAC personnel will also continue to define the user interface and distributed processing methodology and oversee the actual development of this software by contractors. IPAC is also responsible for coordinating and maintaining the distributed operations of the ADS.

W92-70300 **399-50-00**
Ames Research Center, Moffett Field, CA.
THE NATURE OF INTERSTELLAR DUST, ICES AND POLYCYCLIC AROMATIC HYDROCARBONS
L. J. Allamandola 415-604-6890

The objective of this RTOP is to analyze spectroscopic data taken from spacecraft in the vacuum ultraviolet and infrared spectral regions to study the chemical composition and physical state of interstellar dust, ices, and polycyclic aromatic hydrocarbons (PAHs). The approach of this RTOP is to use laboratory produced data to direct the observing strategy used on satellites with spectroscopic capabilities in the vacuum ultraviolet and infrared spectral regions. The laboratory data on PAHs, in interstellar dust, and ices shows very specific signatures of these materials in spectral regions never measured. These regions will be studied with soon-to-be-launched spacecraft. This laboratory data, and other experiments performed as needed, will be used to interpret the observations from these spacecraft. This analysis affords the potential of (1) discovering new and important interstellar molecules, (2) determining the deuterium distribution in interstellar ices and PAHs, and (3) identifying some specific interstellar PAHs based on their far-IR spectra.

EOS Data Information System

W92-70301 **428-81-00**
Langley Research Center, Hampton, VA.
EOS DATA INFORMATION SYSTEM
William L. Grose 804-864-5820

The objective of this RTOP is to support data information system activities for Earth Observing Systems (Eos) interdisciplinary science investigation. Specific tasks include: (1) specification and design of a data processing and analysis system; (2) development of algorithms and analysis software; and (3) development and/or modification of atmospheric simulation models.

W92-70302 **428-81-04**
Goddard Space Flight Center, Greenbelt, MD.
EOS
J. R. Bates 301-286-7482

The objective of this investigation involves the development of a data assimilation system for Earth Observing System (Eos) consisting of the following components: (1) an atmospheric general circulation model, (2) an objective analysis scheme, (3) an initialization procedure, and (4) a retrieval scheme for inverting satellite radiances.

W92-70303 **428-81-06**
Goddard Inst. for Space Studies, New York, NY.
INTERANNUAL VARIABILITY OF GLOBAL CYCLES
James E. Hansen 212-678-5619
(429-81-06)

The objective is to investigate the interannual variability of key global parameters and processes in the global carbon, energy, and water cycles. Specifically, the investigation will develop, analyze, and make available global geophysical data sets derived from pre-Eos and Eos observations in combination with models. The strategy is to focus on analysis of interannual variability in data sets; this should yield information on key earth science processes, without the requirement of waiting until long-term trends are apparent. Such attempts to use pre-Eos and Eos data as soon as possible will be crucial to refined definition of Eos observing and data systems.

W92-70304 **428-81-16**
Goddard Space Flight Center, Greenbelt, MD.
GLOBAL HYDROLOGIC CYCLE
Albert Arking 301-286-7208
(578-81-16; 429-81-16)

The objective of this RTOP is to improve the understanding of the physical mechanisms of the atmospheric hydrological processes; the role of hydrologic processes in large scale ocean-atmosphere-land interaction leading to natural fluctuation of the global climate system over a variety of time scales; and the role of land surface processes, including storage, in the global hydrologic cycle, with emphasis on the interaction and integration of regional to global scales. The approach is to make extensive use of data collected from existing satellite missions and from Earth Observing System (Eos); to use results obtained for the pre-Eos phase to provide guidance for instrument design in the launch phase and to further the understanding of global hydrologic processes through model development and data analysis; and to emphasize a synergistic approach based on analysis of data from space and non-space platforms as well as modeling.

W92-70305 **428-81-26**
Goddard Space Flight Center, Greenbelt, MD.
BIOSPHERE ATMOSPHERIC INTERACTIONS
Piers J. Sellers 301-286-4173

A global atmosphere general circulation model will be forced with surface data sets derived from Advanced Very High Resolution Radiometer (AVHRR) data to calculate surface-atmosphere fluxes of energy, heat, water, and CO2. Regional ecology models will be developed.

W92-70306 **428-81-36**
Goddard Space Flight Center, Greenbelt, MD.
EOS IDS, EOSDIS MONEY
Mark R. Schoeberl 301-286-5819

The investigation is a two-component effort to characterize both the short- and long-term stratospheric changes which have occurred and will occur over the period beginning with Nimbus 7 observations in late 1978, continuing with the Upper Atmosphere Research Satellite (UARS) and on through the Eos observing period. The first part of this proposal involves the generation of climatological data sets for ozone, temperature and trace gases (N2O, CH4, NO2, NO). These data sets will be made available to the EosDIS (Eos Data and Information System) during definition phase for use by other interdisciplinary and instrument investigators. The second part of the investigation is to study natural and anthropogenic changes in the stratosphere as revealed by the climatological data sets. In particular, interest is in being able to separate natural and anthropogenic processes in order to better assess the exact magnitude of anthropogenic changes and understand the natural chemical/dynamical/radiative interaction and feedback processes within the stratosphere. The data assimilation model and other 2- and 3-D models are proposed to facilitate the generation of the climatological data sets mentioned above as well as undertake the theoretical investigations. This

RTOP area concerns the upgrade of computer facilities to accomplish this investigation.

W92-70307 **428-81-80**
Goddard Space Flight Center, Greenbelt, MD.
EOS DIS FOR IDS ON BIOGEOCHEMICAL FLUXES AT AIR/SEA INTERFACE
Anne M. Thompson 301-286-2629

The objective of this RTOP is to set up framework for satellite data input, model analysis and output to be delivered to Eos DIS (Data and Information System). Pre-launch of these satellites will use existing data sets (e.g., Coastal Zone Color Scanner, CZCS) and post-launch data from MODIS (Moderate Resolution Imaging Spectrometer), STIKSCAT, AMSU (Advanced Microwave Sounding Unit), MOPPITT/TRACER, and other instruments. Data processing for the task is likely to take transfer velocities and dissolved trace gas distributions from other members of the Eos team to produce flux maps. Fluxes will be used in the photochemical model to produce lower tropospheric distributions of DMS, SO2, and CO. Another objective is to use existing data sets and model to make N calculations on grid appropriate for GCM (General Circulation Model). Monthly averaged data sets are to be used initially. The current tropospheric 1-D model will be the basis for N calculations. This RTOP deals with the computational requirements of this investigation. It will include updating of hardware and software to accomplish on large grid (N computations) what we have been doing in a single computation mode on local VAX 11/780. Hardware choices will be made to insure compatibility and efficient data transfer among Eos team members, both at GSFC and WHOI (Woods Hole Oceanographic Institute).

W92-70308 **428-81-99**
Goddard Space Flight Center, Greenbelt, MD.
STUDIES OF VOLCANIC SO2
Arlin J. Krueger 301-286-6358

The objective of this RTOP is to develop an Eos data base of volcanic eruptions derived from TOMS (Total Ozone Mapping Spectrometer) sulfur dioxide analyses. Data sources are the TOMS instruments on Nimbus 7, Meteor-3, Earth Probes, ADEOS and NOAA satellites, and AVHRR and thermal IR sounders on NOAA satellites. The product will be daily files and maps containing the content and spatial distribution of the sulfur dioxide in eruption clouds. This information is potentially useful in volcano-climate studies, volcanology, as material tracers in meteorological studies, and in development of volcanic hazard abatement techniques.

W92-70309 **428-82-01**
Goddard Inst. for Space Studies, New York, NY.
GLOBAL CLOUD CLIMATOLOGY (ISCCP OPERATIONS)
William B. Rossow 212-678-5567

The objective of this RTOP is to develop and apply techniques of extraction of cloud optical properties to satellite observations to produce cloud climatology data sets; to participate in the International Satellite Cloud Climatology Project (ISCCP) as the Global Processing Center to produce a twelve year global cloud climatology; and to also participate in data and analysis comparisons to validate the global climatology.

W92-70310 **428-82-02**
Goddard Space Flight Center, Greenbelt, MD.
RADAR-ALTIMETER ICE DATA SYSTEM
H. Jay Zwally 301-286-8239

This RTOP covers (1) processing of satellite radar altimetry data acquired over polar ice by Geosat, the European ERS-1, and TOPEX; (2) calculation and evaluation of various corrections; (3) compilation and validation of level 1 through 4 data sets of ice elevations and other parameters; (4) maintenance a complete library of ice altimeter data; and (5) operation of a computer system for altimeter data.

W92-70311 **428-82-06**
Goddard Space Flight Center, Greenbelt, MD.
OCEAN COLOR DATA SYSTEM
Robert G. Kirk 301-286-7895

This RTOP covers the NASA in-house program associated with the POP for the SeaWiFS spaceflight system. It consists of management costs; data receipt, processing, and distribution; and algorithm and validation programs.

W92-70312 **428-82-11**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
AUTOMATED GEOPHYSICAL PROCESSOR DEVELOPMENT FOR THE ALASKA SAR FACILITY
R. Kwok 818-354-5614

The long-term objective is to develop a geophysical processor system for ice and ocean studies that is capable of automated data processing producing a classification of ice types and an extraction of ice motion parameters from multi-date Synthetic Aperture Radar (SAR) imagery. The goal is to provide data products that can be directly utilized for the analysis of large-scale ice dynamics in the polar regions as well as for practical applications such as navigation and deployment of drilling platforms. As a means to this goal, new data extraction and image processing techniques will be developed under this RTOP and integrated into an operational system for ice information extraction from SAR imagery. This system will be evaluated using SEASAT imagery, with the eventual application of the operational system to process ERS-1 (Earth Resources Satellite) data acquired at the Alaska SAR Facility (ASF) and data from the Japanese Earth Resources Satellite-1 (J-ERS-1), RADARSAT, and the Earth Observation System (Eos) SAR. The approach is to initially develop techniques for ice classification, two-dimensional motion tracking, and extraction of ocean wave parameters that are both reliable and efficient. Additionally, as part of this task system architectures are evaluated that would maximize the autonomy and enhance the performance of the data system. Ice motion tracking is a complex problem due to the translation, rotation, and deformation of the different ice types and because of the high spatial-temporal variability of sea ice. These characteristics mandate the development of new image processing approaches to the classification and tracking problems. The primary tasks include: development of contextual classification techniques for categorization of sea ice; development of feature tracking techniques for identification of image sequences; reasoning methodologies for utilization of spatial constraints and motion predicts from ice dynamics models; extraction of ocean wave parameters from high resolution image spectra; and evaluation and testing of system architectures that are optimal to the implementation of such a system. These capabilities will be initially developed for E-ERS-1 and then modified for the J-ERS-1 and RADARSAT data sets.

EOS Science

W92-70313 **429-81-04**
Goddard Space Flight Center, Greenbelt, MD.
EOS
J. R. Bates 301-286-7482

The investigation involves the development of a data assimilation system for Earth Observing System (EOS) consisting of the following components: (1) an atmospheric general circulation model; (2) an objective analysis scheme; (3) an initialization procedure; and (4) a retrieval scheme for inverting satellite radiances.

W92-70314 **429-81-06**
Goddard Inst. for Space Studies, New York, NY.
INTERANNUAL VARIABILITY OF GLOBAL CYCLES
James E. Hansen 212-678-5619
(428-81-06)

Our objective is to investigate the interannual variability of key global parameters and processes in the global carbon, energy and water cycles. Specifically, our investigation will develop, analyze, and make available global geophysical data sets derived from pre-EOS and EOS (Earth Observing System) observations in combination with models. Our strategy is to focus on analysis of interannual variability in data sets; this should yield information on key earth science processes, without the requirement of waiting until long term trends are apparent. Such attempts to use pre-EOS and EOS data as soon as possible will be crucial to refined definition of EOS observing and data systems.

W92-70315 **429-81-10**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
ROLE OF AIR-SEA EXCHANGES AND OCEAN CIRCULATION
W. T. Liu 818-354-2394
(428-81-10)

This is an interdisciplinary science investigation of NASA's Earth Observing System (EOS) Program. The objective is to study the role of ocean circulation and the ocean-atmosphere exchanges in affecting global climate changes. Methods to compute ocean surface heat, momentum, and water fluxes using satellite data are being improved. The responses of the ocean to these forcings will be examined. Tropical ocean-atmosphere interaction will be studied. The energy and hydrologic balances of the coupled ocean-atmosphere system will be examined. Eddy resolving general circulation models to assimilate satellite data and to provide a realistic 4-D description of ocean circulation will be developed. We will extend and join our funded studies in satellite missions such as ESA Remote Sensing Satellite (ERS-1), NASA Scatterometer (NSCAT), Topology Ocean Experiment/Poseidon (Topex/Poseidon), and Tropical Rain Measuring Mission (TRMM). We will utilize our established participation and leadership in the field experiments, monitoring programs, and modeling efforts of TOGA (Tropical Ocean and Global Atmosphere) and WOCE (World Ocean Circulation Experiment). We will draw upon operational satellite data and will follow closely the development of data systems such as ISCCP (International Cloud Climatology Project), Wetnet, GPCP (Global Precipitation Climatology Project), and SRB (Surface Radiation Budget) Project. We will contribute to the Global Energy and Water Cycle Experiment (GEWEX) as soon as it is ready to address problems over the ocean. These studies will pave the way for the era of EOS platforms.

W92-70316 **429-81-16**
Goddard Space Flight Center, Greenbelt, MD.
GLOBAL HYDROLOGIC CYCLE
Albert Arking 301-286-7208
(578-81-16; 428-81-16)

The objectives of this RTOP are as follows: to improve our understanding of the physical mechanisms of atmospheric hydrologic processes, role of hydrologic processes in large scale ocean-atmosphere-land interaction leading to natural fluctuation of the global climate system over a variety of time scales, and role of land surface processes, including storage, in the global hydrologic cycle, with emphasis on the interaction and integration of regional to global scales. The approach will be to make extensive use of data collected from existing satellite missions and from EOS, results obtained for the pre-ECS phase will be used to provide guidance for instrument design in the launch phase and to further our understanding of global hydrologic processes through model development and data analysis, and a synergistic approach based on analysis of data from space and non-space platforms as well as modeling will be emphasized.

W92-70317 **429-81-26**
Goddard Space Flight Center, Greenbelt, MD.
BIOSPHERE ATMOSPHERIC INTERACTIONS
Piers J. Sellers 301-286-4173

A global atmosphere general circulation model will be forced with surface data sets derived from Advanced Very High Resolution Radiometer (AVHRR) data to calculate surface-atmosphere fluxes of energy, heat, water, and CO2. Regional ecology models will be developed.

W92-70318 **429-81-36**
Goddard Space Flight Center, Greenbelt, MD.
EOS IDS, STRATOSPHERIC TEMPERATURE AND TRACE GAS TRENDS
Mark R. Schoeberl 301-286-5819

The investigation is a two-component effort to characterize both the short and long term stratospheric changes which have occurred and will occur over the period beginning with Nimbus 7 observations in late 1978, continuing with Upper Atmosphere Research Satellite (UARS) and on through the Earth Observing System (Eos) observing period. The first part of this proposal involves the generation of climatological data sets for ozone, temperature and trace gases (N2O, CH4, NO2, NO etc.). These data sets will be made available to the Earth Observing System Data Information System (EosDIS) during definition phase for use by other interdisciplinary and instrument investigators. The second part of the investigation is to study natural and anthropogenic changes in the stratosphere as revealed by the climatological data sets. In particular, we are interested in being able to separate natural and anthropogenic processes in order to better assess the exact magnitude of anthropogenic changes and understand the natural chemical/dynamical/radiative interaction and feedback processes within the stratosphere. We propose to use the data assimilation model and other 2-D and 3-D models to facilitate the generation of the climatological data sets mentioned above as well as undertake the theoretical investigations.

W92-70319 **429-81-38**
Langley Research Center, Hampton, VA.
EOS SCIENCE
William L. Grose 804-864-5820

The objective of this RTOP is to improve understanding of atmospheric processes which influence global change and thereby contribute to the interdisciplinary Earth Science investigations being carried out as a part of the Earth Observing System (Eos) program. Specific tasks include: (1) studies of the role of clouds in the Earth's radiant energy budget; and (2) observational and modeling studies of radiative, chemical, and dynamical interactions in the Earth's atmosphere.

W92-70320 **429-81-64**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
POLAR EXCHANGE AT THE SEA SURFACE: JPL COMPONENT
F. D. Carsey 818-354-8163

Research will be conducted in the generation of algorithms for sea ice geophysical fluxes from satellite data with a focus on the Weddell and Greenland Seas. The objective of this work is the accurate, routine estimation of heat, brine and momentum fluxes from sea ice. The basic approach is the merging of data from Special Sensor Microwave Imager (SSM/I) and Alaska Synthetic Aperture Radar (SAR) Facility Geophysical Processor System (ASF-GPS). Specifically we plan in 1992 to: (1) Utilize the ASF-GPS with properly processed SSM/I data in studies of algorithms to generate the surface heat and brine fluxes of the Greenland Sea as part of the Greenland Sea Project; and (2) Examine the consequences of errors and general data characteristics of the ASF-GPS and SSM/I data streams. It will be necessary to initiate geophysical flux estimation production through the latter part of the decade, including particularly the flight phase of RADARSAT and Earth Observing System (Eos). In the Greenland Sea our approach is to use SAR data to track the ice and estimate opening and closing while using SSM/I data and

weather analyses to estimate thickness changes with time. A key element of the flux analysis is the use of ice motion data in the conversion of SSM/I Tbs to ice thickness changes; we have modeled the expected changes in Tb, and we will next check the sensitivity of this calculation to errors and gaps in the ice motion field as generated on the SAR schedule of 1 to 2 velocity determinations per week. The ice-motion gaps arise in two ways; some ice is simply missed by the limited sampling procedure of the narrow-swath SAR (or the cloud-limited Advanced Very High Resolution Radiometer (AVHRR)), and some ice motion data are missed if the changes in the ice cover between SAR observations is great enough. At present the specific robustness of the GPS analysis to ice cover changes had not been assessed. Finally the accuracy of ice motion to predict actual opening and closing has not been tested. This testing will be part of the GPS validation performed under the ASF-NRA. There is a key need for analyses of the sort discussed here. In the next year we will use ice motion data from AVHRR, just received from the Danish scientists in the Greenland Sea Project; later we will use ESA Remote Sensing Satellite (ERS-1) SAR derived data.

W92-70321 **429-81-68**
Marshall Space Flight Center, Huntsville, AL.
EARTH OBSERVING SYSTEM SCIENCE
R. J. Koczor 205-544-3078

Major objectives are: (1) Determine the mechanisms and rates of transfer of water between the major global reservoirs; (2) What are the dynamics of the major reservoirs of freshwater in relation to weather, climate, the Earth's energy budget, and global water supply; (3) How will the distribution, volume, and fluxes of water change as a result of human activities and climate variability; and (4) How is the water cycle coupled to other components of the Earth System. The approach to answering these questions is a complementary program of observational studies, focused process studies, and development of integrated conceptual and predictive models. The research is cooperative in nature with scientists from the Pennsylvania State University. The broad base of the combined Marshall Space Flight Center and Pennsylvania State University research team optimizes scientific expertise required for these interdisciplinary tasks.

W92-70322 **429-81-72**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
PROJECT TO INTERFACE MODELING
R. W. Zurek 818-354-3725
(428-81-72)

The unique observational capabilities provided by the Earth Observing System (Eos) program have the potential for driving major improvements in climate models at the global and regional scale. The NCAR Eos Project to Interface Climate Modeling on Global and Regional Scales with Eos Observations is a selected interdisciplinary investigation designed to work synergistically between the selected Eos measurement capabilities, detailed research on the physical mechanisms of climate change, and the development of global climate and global change models. The emphasis is on surface and atmospheric processes related to the hydrological cycle. In parallel with the National Center for Atmospheric Research's (NCAR) climate modeling program, the project will focus on the sensitivity of climate models to Eos observations, the framework for the assimilation of Eos data needed for climate models, the application of Eos data sets to model validation and as model boundary conditions, and development of climate model parameterizations and diagnostics that are more compatible with remotely sensed (satellite) data than those at present. The project will also carry out prototype applications of currently available data sets to improve our framework for relating Eos data to climate models. New approaches to the analysis of satellite data will be developed, as applicable to the Eos sensors and to the validation of model simulations. This includes new and modified approaches to archiving and visualization of global satellite data and model simulations, as needed.

W92-70323 **429-81-80**
Goddard Space Flight Center, Greenbelt, MD.
IDS SCIENCE FOR WHOI/GSFC EOS PROJECT: BIOGEOCHEMICAL FLUXES AT THE AIR-SEA INTERFACE
Anne M. Thompson 301-286-2629
(429-81-36; 429-81-99)

An objective is to compute sea-to-air fluxes of the photochemically reactive gases DiMethyl Sulfide (DMS) and CO using ocean color, UV and lower atmosphere dynamic data and to calculate boundary layer concentrations of DMS, CO, and SO2 and related trace constituents. Monthly mean maps are to be produced. Another objective is to be achieved in parallel with similar research for Schoeberl/Strat, Chemistry EosIDS. Flux computation will be made from pre-launch data sets which will include Coastal Zone Color Scanner (CZCS) (and Sea-WIFS (Wide Field Instrument), if launched). Eos data needed are ocean color from MODIS, surface temperature and winds from STIKSCAT, AMSU, LAWS. Photochemical Calculation will be made from N x 1-D computations with GSFC 1-D tropospheric photochemistry model using MOPPITT/TRACER CO, O3 (from Eos-A, e.g., HRDLS; from Eos-B, TES), and other data to constrain tropospheric OH. Pre Eos data to use TOMS, and marine boundary layer trace gas and meteorological data from cruises (e.g., SAGA 3, 1990; PSI 1 and 2; 1989, 1990; dedicated WHOI/Eos cruise - 1994) appropriate for model validation and construction of data sets for EosDIS.

W92-70324 **429-81-94**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
GLOBAL ASSESSMENT OF ACTIVE VOLCANISM
D. C. Pieri 818-354-6299
(428-81-94)

Support is requested in this RTOP for science activities to be carried out under sponsorship of the Earth Observing System (Eos) Volcanology Interdisciplinary Science Team. Science activities here are related to science algorithm development as outlined in the revised Volcanology IDS Proposal entitled, A Global Assessment of Active Volcanism, Volcanic Hazards, and Volcanic Inputs to the Atmosphere from the Earth Observing System. Work under this RTOP is directed toward the remote sensing of the thermal properties of active volcanoes during eruptions as well as during quiescent baseline periods. Specific activities in the thermal area to be carried out under this RTOP are: (1) remote detection of volcanic eruptions by thermal anomaly recognition; (2) remote determination of surface temperature distributions of active lava flows; and (3) determination of long term thermal energy budgets for active volcanoes. During the operational phase of Eos, these observations will be carried out using the near-mid-, and thermal-IR bands of Moderate Resolution Imaging Spectrometer-Nadir (MODIS-N) and Advanced Very High Resolution Radiometer (ASTER) instruments. Part of the algorithm development for (1) will involve the creation of an alarm system that will scan incoming MODIS-N data daily to alert Team members of anomalously high thermal spikes over volcanic areas. The monitoring of actively flowing lavas in (2) will require systematic data acquisitions with the ASTER instrument High Resolution Imaging Spectrometer (HIRIS on Platform B) throughout available IR bands. Determination of thermal budgets in (3) will require the development of long term IR data bases over relevant active volcanoes to monitor pre-, syn-, and post-eruption thermal fluxes. Prelaunch activities involve development of analog data sets using Advanced Very High Resolution Radiometer (AVHRR) and airborne data over active volcanoes.

W92-70325 **429-81-95**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
GLOBAL ASSESSMENT OF ACTIVE VOLCANISM (DATA ANALYSIS)
H. A. Zebker 818-354-8780
(428-81-95)

This RTOP, in conjunction with the related RTOP 428-81-95, is part of the Earth Observing System (Eos) Interdisciplinary Science proposal, Global Assessment of Active Volcanism, headed by Dr. Peter Mouginis-Mark of the University of Hawaii. Our role in this

overall study is to develop the means to map active volcanoes topographically using interferometric Synthetic Aperture Radar (SAR) data acquired by the Eos SAR, ESA Remote Sensing Satellite-1 (ERS-1), RADARSAT, and any other available orbital SARs. This specific job number covers the science investigation expenses. The orbital SARs will provide data from which we may derive topographic maps of 10 m height accuracy over images tens of kilometers in extent at a spatial resolution of 20 to 30 m. It may also be possible to generate topographic change maps, on a relative rather than absolute scale, sensitive to cm scale changes in height that may serve as precursors to eruptive events. Topographic measurements before and after volcanic events will permit estimation of displaced volumes of material following explosive activity, which are extremely important in estimation of the atmospheric effects of Alaskan eruptions and their influence on climate. Local climate conditions are also effected by the interaction of lava flows on frozen ground and ice sheets. While not explicitly part of this investigation, an understanding of the latter effect would be of major importance in hazard assessment in regions such as Iceland where melting of ice during an eruption is significant. These measurements derived from radar data are especially applicable in the study of active volcanism, where conventional monitoring using optical sensors or in situ measurements are either infeasible due to atmospheric obstruction at optical wavelengths or too dangerous for manned exploration. However, such monitoring is necessary both for hazard assessment of active eruptions and for understanding the past history and long-term effects of the eruptions on local, and in extreme cases, global climate.

W92-70326 **429-81-96**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
GLOBAL ASSESSMENT OF ACTIVE VOLCANISM
J. A. Crisp 818-354-9036
(428-81-96)

One objective is to develop an algorithm for an eruption alarm based on the detection of an SO2 anomaly by Moderate-Resolution Imaging Spectrometer (MODIS). Algorithms will also be developed for estimating SO2 concentrations in volcanic plumes, using data from MODIS and Atmospheric Infrared Sounder (AIRS). Another objective is to provide input to the TES and MLS teams for volcanology study requirements (maps of SO2, HCl, and HF concentration) and to prepare for the analysis of the data that will be provided by these teams by studying pre-Eos (Earth Observing System) analog datasets. The ultimate objectives for the Eos execution phase will be to produce global maps showing the distribution and timing of SO2 alarms and the size of SO2 anomalies. Assessments will be made of the annual contribution of volcanoes to the global budget of SO2 and the related climate effect. The Eos data will also be used to study the relationship between magmatic activity and fluctuations in SO2 emissions and the ratio SO2/HCl, which are useful in the study of volcanic hazards and magma chamber conditions. SO2 estimates from MODIS and AIRS data will be compared with aerosol maps produced by other Eos instruments to study the conversion from SO2 into sulfate aerosols. The SO2 alarm and measurement algorithms will be developed and tested by running radiative transfer simulations and by studying pre-Eos analog datasets. Continued communication with the TES and MLS teams will be maintained to ensure that we are prepared for analysis of the SO2 and HCl data that these teams will provide.

W92-70327 **429-81-97**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
GLOBAL ASSESSMENT OF ACTIVE VOLCANISM
A. B. Kahle 818-354-7265
(428-81-97)

The overall objective, as an accepted team member, is to participate in the Earth Observing System (Eos) Interdisciplinary Science Study entitled, A Global Assessment of Active Volcanism, Volcanic Hazards, and Volcanic Inputs to the Atmosphere from the Earth Observing System. In the coming year algorithm development will continue. Those algorithms for which I have the prime responsibility include no. 18 Low Temperature Volcanic Thermal Anomalies, and no. 21 Atmospheric Profiles. Others, to which I will also contribute, include no. 1 Eruption Detection by Thermal Spike, no. 4 Eruption Plume Temperature, no. 15 Temporal Change in Volcano Morphology, no. 16 Lava Flow Temperature Distribution, and no. 23 Supplemental Data Sets.

W92-70328 **429-81-99**
Goddard Space Flight Center, Greenbelt, MD.
STUDIES OF VOLCANIC SO2, THEORY
Arlin J. Krueger 301-286-6358

The objective of this RTOP is to develop algorithms for retrieval of sulfur dioxide column amounts from UV radiances measured with Total Ozone Mapping Spectrometer (TOMS) instruments, and for assessment of associated parameters, such as plume height and velocity. Data sources are the TOMS instruments on Nimbus 7, Meteor-3, Earth Probes, Advanced Earth Observing System (ADEOS) and NOAA satellites, and Advanced Very High Resolution Radiometer (AVHRR) and thermal IR sounders on NOAA satellites. This information is potentially useful in volcano-climate studies, volcanology, and as material tracers in meteorological studies.

Space Physics Theory

W92-70329 **431-06-00**
Goddard Space Flight Center, Greenbelt, MD.
SPACE PHYSICS THEORY PROGRAM (SPTP)
T. J. Birmingham 301-286-7110

The subject RTOP supports a program of theoretical analysis and computer modeling carried out by 17 autonomous groups (cf Form 1471A), all but one of which are external to NASA. SPTP has been in continuous existence since FY-79, but until FY-91 funding was directly from NASA Headquarters. The purpose of the program is to carry out independent, fundamental space physics research of a complementary nature and in a continuous manner in each and all discipline areas falling under the purview of the Space Physics Division. The scientific scope of each effort is sufficient to require the existence of a sizable group of co-located investigators working synergistically. Operating in this manner, the SPTP provides theoretical independence and programmatic balance to space plasma physics. Its output is in the forms of peer-reviewed papers published in professional journals and in the input to NASA projects which participants provide, either formally through panels, workshops, and studies, or informally through liaisons with experimental and observational groups.

Space Physics SR&T

W92-70330 **432-20-00**
Goddard Space Flight Center, Greenbelt, MD.
SOLAR WIND-MAGNETOSPHERE-IONOSPHERE COUPLING, MAGNETIC FIELD MODELING, AND MAGNETOTAIL DYNAMICS
James A. Slavin 301-286-5839

This research effort consists of seven distinct tasks directed at furthering our knowledge and understanding of the global solar wind - magnetosphere - ionosphere coupled system. Task 1 will conduct modeling studies of barium chemical releases with the objective of developing better diagnostics for the measurement of field aligned electric potential drops over the auroral regions and

high altitude mapping of magnetospheric L-shells in support of magnetic field modeling studies. Task 2 investigates solar wind - magnetosphere coupling through the use of recently developed predictive filtering and nonlinear chaos modeling techniques. Task 3 examines the structure and dynamics of the earth's magnetotail through a balanced mixture of theoretical and data analysis modeling studies. Task 4 conducts comparative studies of planetary magnetotails with the goal of better understanding this important class of astrophysical phenomena. Task 5 investigates the processes by which solar wind plasma enters the magnetospheric cusps and penetrates to low altitudes. Task 6 conducts data analysis and theoretical modeling studies of recently discovered magnetic bubbles in the equatorial ionosphere rising upward to greater altitudes. Task 7 consists of theoretical modeling studies directed toward the investigation and representation of the major magnetospheric current systems and the magnetic fields they generate. Taken together, these investigations offer a well balanced Goddard Space Flight Center/Lab. for Extraterrestrial Physics (GSFC/LEP) research program addressing most key aspects of solar wind - magnetosphere - ionosphere coupling.

W92-70331 **432-20-00**
Marshall Space Flight Center, Huntsville, AL.
MODELING OF CORE PLASMA
D. L. Gallagher 205-544-7587

The objectives include the continued development of magnetospheric empirical models of ionic density, composition, and temperature. The existing hydrogen model will be extended to include a range of geophysical conditions and latitudes. The development of an empirical model will be extended to include a range of geophysical conditions and latitudes. The development of an empirical model of hydrogen temperatures will also be completed. Helium and oxygen empirical models will be similarly developed, based on previous experience. The intent is to further distinguish the geophysical conditions that bring about inner magnetospheric states and to provide analytical models of these states to the research community.

W92-70332 **432-20-00**
Goddard Space Flight Center, Greenbelt, MD.
SINGLE EVENT PHENOMENON DATA GATHERING
Stephen K. Brown 301-286-5795

The objective of this RTOP is to develop an in-house capability to study single event phenomena (SEP) in new microelectronic devices proposed for Goddard Space Flight Center (GSFC) and NASA experiments and projects. This would provide quick response investigations to meet projects needs. The work would be done at the tandem accelerator at Brookhaven National Laboratory, which has been modified and adapted to efficiently accomplish this sort of work. Data on flight electronics resulting from this effort would also be entered into the GSFC Microelectronics Radiation Effects Databank and into other national databanks for use by systems designers. The approaches to be used include the following: (1) establishing working procedure for tests and data handling at Brookhaven, Data Radiation at GSFC; (2) assembling hardware and software necessary for tests and data handling at Brookhaven and data reduction at GSFC; and (3) assembling a team of personnel to provide technical direction, data analysis, field technician, and engineering support. Present personnel who are associated with the Radiation Test Facility, Combined Release and Radiation Effects Satellite (CRRES) and Cosmic Ray Upset Experiment (CRUX) programs and are already experienced with similar hardware, software, and research can be utilized on a part-time basis.

W92-70333 **432-36-00**
Goddard Space Flight Center, Greenbelt, MD.
PLASMA SCIENCE AND INSTRUMENT DEVELOPMENT
Alex J. Klimas 301-286-3682

This RTOP covers tasks related to both plasma science investigations and to the conception, design, development, and testing of new instrumentation for such investigations. Science objectives include understanding the response of cometary plasmas to changes in the solar wind and interplanetary magnetic field. Ground based imagery and spectroscopy of Halley's Comet obtained by the International Halley Watch will be used along with the Halley Armada and other spacecraft data to derive cause-and-effect relationships between coma ion changes and plasma-tail activity on the one hand, and solar wind/Interplanetary Magnetic Field (IMF) structures such as high speed streams and sector boundaries on the other. New instrumentation is being developed for the measurement of ions and electrons with suprathermal energies through a collaboration with the University of Maryland. Exceptionally high time resolution spectral acquisitions are emphasized. A high time resolution magnetic spectrograph for electron measurements has been developed to an engineering model. A new method for remote sensing of near-Earth plasma regimes which could provide information on magnetospheric boundary positions, structures, and dynamical motions is under investigation. The use of a space based radio transmitter and receiver which will sound out remote plasma regions is under investigation. Detailed plasma and wave interaction theories are being applied along with ray tracing calculations in a model magnetosphere in order to understand signal loss, refraction, and reflection of the sounder waves in the various near-Earth plasma regimes. The interactions among dust grains and plasma in planetary rings, magnetospheres, and in comets is under investigation. Recent developments include a better understanding of solar wind loading of ions produced from cometary neutrals. Work on coagulation of dust in a plasma has continued. This subject of the properties of dusty plasma is a relatively new subdiscipline of plasma physics, and one of particular astrophysical interest. A comprehensive investigation of electron plasma physics in the terrestrial bow shock-foreshock system is under way to better understand the most fundamental one species, one dimensional, electrostatic plasma. Extensive observations in Earth's foreshock remain to be interpreted. The persistence of bump-on-tail unstable electron velocity distributions and the excitation of broad band down shifted Langmuir waves are under consideration. Using International Sun-Earth Explorers (ISEE) solar wind, foreshock, and bow shock observations, a model of the bow shock-foreshock system has been constructed. Extensive numerical simulations of the foreshock electron plasma within the context of the model are under way.

W92-70334 **432-36-00**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
MAGNETOSPHERIC COUPLING
R. Goldstein 818-354-0241

This RTOP consists of 2 subtasks: (1) Cometary Plasma Physics Using Data from the Giotto Mass Spectrometer which include analysis of Giotto/Halley comet plasma data for wave processes and energy transport; and (2) Jovian Magnetospheric Processes which include analysis of time variability of Jovian decimetric (synchrotron) radiation with ground-based radio telescopes, and comparison of results with theoretical models.

W92-70335 **432-36-00**
Goddard Space Flight Center, Greenbelt, MD.
COORDINATED DATA ANALYSIS WORKSHOP (CDAW) PROGRAM
Robert E. McGuire 301-286-7794
(433-90-00)

As our understanding of solar-terrestrial systems such as the earth's magnetosphere and the heliosphere matures, many of the significant questions that remain concern global-scale, 3-D structure and dynamics. These questions are a major focus of the key space physics missions of the 1990s, specifically the International Solar Terrestrial Physics (ISTP) program and the NASA-led Global Geospace Science (GGS) portion thereof. The analysis of simultaneous data assembled from many instruments widely dispersed in space, with the analysis closely linked to theoretical models, is one essential element in the successful resolution of such questions. This RTOP is to support new series of Coordinated Data Analysis Workshops (CDAWs) aimed at: (1) immediate exploitation of existing opportunities for fruitful collaborative

research workshops; (2) refining the organizational techniques and software tools to support the effective/efficient simultaneous analysis of the multiple data collections needed to address such global problems; and (specifically) (3) defining, testbedding and then implementing the coordinated event-mode analysis program that is now projected to be the primary and critical focus of ISTP global-scale science. Of the greatest immediate importance and impact, the FY-92 ISTP Data Testbed program proposed in this RTOP represents a critical step to allow the rapid evolution of the CDAW concepts into the now-envisioned primary focus for ISTP/GGS global event-mode science. For FY-92, basic support for the current CDAW-9 effort will be folded under the general auspices of the Space Physics Division support for IACG activities.

W92-70336 **432-48-00**
Marshall Space Flight Center, Huntsville, AL.
MAGNETOSPHERIC ROLE OF IONOSPHERIC PLASMA
T. E. Moore 205-544-7633

The purpose of this effort is to investigate the role played by ionospheric plasma in the dynamics of the magnetosphere. By this, we mean the influence of the transport and circulation of ionospheric plasma on the dynamical processes of the magnetosphere. A special focus of this study will be the interactions between cool plasma emanating from the ionosphere and the hotter plasma populations found at higher altitudes. This study will build on earlier work based upon two basic tools: (1) a semi-kinetic model of ionospheric plasma; and (2) a particle trajectory tracing model of the motions of superthermal ionospheric particles within plausible 3-D models of the magnetospheric fields.

W92-70337 **432-48-00**
Marshall Space Flight Center, Huntsville, AL.
EXPERIMENTAL AND THEORETICAL STUDIES OF NATURAL AND INDUCED AURORAS AND AIRGLOW
M. R. Torr 205-544-7591

The purpose of this RTOP is to conduct studies to advance our knowledge of the physics of auroras and airglow, and to extend our ability to use the measurement of auroral emissions for the interpretation of magnetospheric phenomena. A primary objective is the modeling of auroral emissions in order to characterize the impact energy of the particles. Our approach is to use a well developed interhemispheric model to study the principal thermospheric emissions on a global scale. In addition, an ab initio auroral model will be superimposed on the global emission model, thus permitting separation of auroral from photochemical effects, conjugate from local effects, local from transport effects, etc.

W92-70338 **432-48-00**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
ELECTRON IMPACT CROSS SECTIONS FOR PROCESSES OF IMPORTANCE IN IONOSPHERES AND MAGNETOSPHERES
R. Goldstein 818-354-0241

The purpose of the Electron Impact Cross Sections for Processes of Importance in Ionospheres task is to generate electron collision cross sections and determine optical (absorption and ionization) f-values of ionospheric interest. The laboratory measurements are coordinated with modelers of planetary atmospheres and compared to theoretical calculations. The Dissociative Ionization and Attachment Processes task consists of laboratory studies of electron impact processes of interest for magnetospheric and ionospheric processes.

W92-70339 **432-48-00**
Goddard Space Flight Center, Greenbelt, MD.
THERMOSPHERE-IONOSPHERE-MESOSPHERE-MAGNETOSPHERE INTERACTIONS
R. E. Hartle 301-286-8234

The basic objective is to study the observed properties of the ionosphere, mesosphere, thermosphere, exosphere and inner magnetosphere, and to identify and understand the physical and chemical processes operating in these regimes, emphasizing how they interact. This is achieved by processing, analyzing and interpreting experimental data derived largely from flight programs after funding from project offices has terminated, permitting the study of long-term phenomena, comparison of data with new theories and models, correlative studies of data obtained from various satellites and ground based observatories, and the deposition of additional data in the National Space Science Data Center. The essential data to be used in this investigation include electron densities and temperatures, ion and neutral composition, neutral winds, ion temperatures and drifts, electric fields, magnetic fields, electromagnetic radiation and energetic particles of magnetospheric and ionospheric origin. These data are used to determine the various interrelated chemical, compositional, dynamical and energetic states of the ionosphere, exosphere, thermosphere and mesosphere and the transport and deposition of mass, momentum and energy in and between these physical regions. These basic properties and processes are then used to analyze specific geophysical phenomena such as atmospheric escape, electric field induced ion drifts in the ionosphere, chemistry and dynamics of mid and high latitude troughs, auroral substorms, ionospheric storms, Joule heating, PCA events, tidal and gravity waves, depletion and filling of plasmasphere, ionospheric electrodynamic processes, equatorial bubble formation, SAR Arcs, etc.

Space Physics ATD

W92-70340 **433-04-00**
Goddard Space Flight Center, Greenbelt, MD.
SPACE PHYSICS MISSION PLANNING
J. L. Cooley 301-286-7379

The objectives and approach of this RTOP include development of new trajectory concepts and orbit-control techniques for space physics missions, and utilization of these, and existing, ideas for a variety of orbital studies for the spacecraft of the Solar-Terrestrial Science (STS) Project of the Inter-Agency Consultative Group (IACG). This work will contribute to a major objective for this RTOP, the preparation of an update to the Handbook on orbits, operations, and coordination for all STS spacecraft for IACG's Working Group 3 (WG-3) on Mission Design and Planning. The Goddard Mission Analysis System (GMAS), Swingby, and other existing orbital design software will be used, and modified, as needed, to calculate new types of trajectories near libration points, and utilizing lunar and Earth-swingby maneuvers. These trajectories, and well-known ones such as periodic halo and double-lunar swingby orbits, will be used for contingency studies, orbit coordination, and extended mission design for the STS spacecraft, and for others in similar orbits. The IACG WG-3 Handbook portrays the STS orbits, showing various options and possibilities for coordinated measurements, and list pertinent spacecraft data. Annual updates to the Handbook will reflect changes in mission plans.

W92-70341 **433-04-00**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
INTERDISCIPLINARY ATD STUDIES
C. L. Yen 818-354-4899

The purpose of this RTOP is to carry out technical studies in support of mission planning activities. The study leader will coordinate with the Jet Propulsion Laboratory advanced studies program manager and provide the technical information needed in formulating program strategies. For selected deep space missions, a thorough investigation of the science needs, mission feasibility and the mission/spacecraft options will be made. This will include advanced propulsion and other technology options.

W92-70342 **433-06-00**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
SOLAR PROBE ATD
J. E. Randolph 818-354-2732

The purpose of this RTOP is to develop phase A mission and system design concepts with sufficient detail to provide reasonable project planning and cost estimates leading to more formal phase B studies in FY-93, and to complete the initial technology development program for the thermal shield by concluding the shield materials development and testing program. Sub-objectives are to conduct spacecraft design and costing studies with industry; complete the shield mass loss effects study on science, under a contract with the University of Kyoto in Kyoto, Japan; utilize the science study team to further develop the instrument requirements and concepts as well as evaluating the science compatibility of the spacecraft system design; to continue the development of a program implementation plan consistent; and to complete the thermal shield characterization and mass loss testing program using at least three industry test facilities. The major design teams to be formed to implement this study are the Solar Probe study team to coordinate all study activities; the science study team to advise the study concerning scientific rationale and payload; the technology development team to carry out shield testing and analysis; and the contract support team to monitor and advise the study contractors.

W92-70343 **433-90-00**
Goddard Space Flight Center, Greenbelt, MD.
GRAND TOUR CLUSTER (GTC)
D. N. Baker 301-286-9188

Just as the International Solar Terrestrial Physics (ISTP) program will provide the first global study of the magnetosphere, the Grand Tour Cluster (GTC) will provide the first comprehensive study of the micro and mesoscale processes of the magnetosphere. This represents a natural extension of the ISTP mission. We emphasize, however, that the physics underlying the GTC represents an entire new frontier when compared to ISTP. Specifically, the physics to be studied in the ISTP will center on the global transfer of energy in the magnetosphere. Once this overview has been obtained, the logical next question concerns the nature of the physical processes that underlie the transfer of energy between various regions of the magnetosphere. ISTP will offer some preliminary insights into these questions, but is simply not equipped to answer the questions which require information on small and intermediate length scales. A different type of mission is required and that is the GTC. The GTC is also the next logical step beyond the ESA CLUSTER mission with its complete magnetosphere tour and variable satellite separation strategies as compared to the single orbit and much less accurate station keeping of the ESA missions. It is envisioned that near the end of the ISTP mission the interaction between theory and experiment will have produced the next generation of quantitative pictures of the global physics of the magnetosphere. The next questions to be asked will involve an investigation of the mesoscale physics that characterize magnetosphere boundary layers and critical regions of the magnetosphere. Much as the development of global three dimensional Magnetohydrodynamic (MHD) simulation codes in the decade preceding ISTP provided an impetus to study global magnetospheric physics in a comprehensive manner, the development of three dimensional hybrid codes which allow scientists to resolve the physics of mesoscale magnetosphere processes during the early to mid 1990's will set the stage for the next generation of magnetospheric missions. These missions will require the use of clustered spacecraft to study widely separated magnetospheric regions. The GTC would offer a moderate cost first step in this in this era of magnetosphere exploration. cost first step in this era of magnetosphere exploration. The GTC would provide the expertise to be asked about the global interaction of mesoscale processes. This could be coupled with the miniaturization expertise to be gained in the proposed Auroral Cluster Mission to design a highly cost effective simultaneous global survey of the magnetosphere using multiple clusters in the next century.

W92-70344 **433-90-00**
Goddard Space Flight Center, Greenbelt, MD.
MELTER
H. G. Mayr 301-286-7505

A Phase-A study for the Mesoscale Lower Thermosphere Explored (MELTER) Mission was conducted three years ago by the University of Michigan. The objective of this RTOP is to revitalize this study and to assess the feasibility for a New Start of the MELTER Mission in 1993.

W92-70345 **433-90-00**
Goddard Space Flight Center, Greenbelt, MD.
IACG (WG-3) AND IACG SUPPORT
Robert E. McGuire 301-286-7794
(432-36-00)

International and NASA space physics programs of the 1990s (e.g., IACG Solar-Terrestrial Science and GGS/ISTP programs) will emphasize multi-spacecraft/multi-agency studies to probe (in situ) the 3-dimensional structure and dynamics of large-scale plasma systems like the Earth's magnetosphere and the solar-terrestrial system. Maximizing the scientific return in these programs (and similar programs in other disciplines) will place an unprecedented emphasis on coordinated science planning and data analysis. Under this RTOP, we propose to continue a multi-year program to build on the existing NSSDC/WDC-A Satellite Situation Center (SSC) and Coordinated Data Analysis Workshop (CDAW) programs to meet IACG science planning and analysis requirements and evolve toward GGS/ISTP support. Elements under this RTOP include: conclusion of the CDAW-9 science activities; SSC support for approved IACG magnetospheric models and region definitions; software integration and enhancements to CDAW and SSC software capabilities for IACG support; a distributed SSC capability (software and database access); and testbed extensions to the existing CDAW concept and capabilities for IACG coordinated data analysis in conjunction with the proposed ISTP Data Testbed and ISTP/CDAW programs as feasible. The basic SSC software port and the switchover of the operational SSC to a UNIX-base were completed in the FY-91 task year. Major progress in the CDAW-9 analyses were also accomplished.

W92-70346 **433-90-00**
Goddard Space Flight Center, Greenbelt, MD.
PRESERVATION AND ARCHIVING OF EXPLORER SATELLITE DATA
R. A. Hoffman 301-286-7386

The NASA Explorer Project Scientists proposed a set of projects whose general objective is to establish archives of spacecraft data for long-term access in a convenient form.

W92-70347 **433-90-00**
Goddard Space Flight Center, Greenbelt, MD.
NSESCC FACILITY
Melvyn L. Goldstein 301-286-7828

The purpose of this RTOP is to support the operating budget of the NASA Space and Earth Sciences Computing Center (NSESCC) associated with very large-scale computational support of RTOP related research within the Space Plasma Physics program. In particular, this RTOP supports much of the super-computing needs of research supported by NASA's Space Physics Theory Program. The funding support of $90K will provide a total allocation of approximately 1000 Computing Units (CUs). The total allocation will be distributed to individual researchers both at Goddard and external universities, in accordance with the computational needs of the space plasma physics community as determined by the RTOP manager in consultation with personnel at NASA Headquarters.

W92-70348 **433-90-00**
Marshall Space Flight Center, Huntsville, AL.
SEI RADIATION RESEARCH
S. H. Morgan 205-544-7576

The objective is to develop and manage a comprehensive research program that addresses the space radiation environment

that will be encountered by humans, materials, and sensitive equipment of the Space Exploration Initiative (SEI) program. Issues include the prediction of solar flares, use of remote sensing to forecast particle fluences, and the characterization of the spectra, composition, and time variability of galactic cosmic rays.

W92-70349 **433-90-00**
Marshall Space Flight Center, Huntsville, AL.
SPACE PHYSICS ADVANCED MISSIONS DEFINITION
C. L. Johnson 205-544-0614

Advanced systems studies and analyses will be performed for the Space Physics Division of candidate future space science missions. Among the missions to be studied are the Inner Magnetosphere Imager (IMI), the Solar Ultraviolet Radiation and Correlative Emissions (SOURCE) Experiment, the Ultra-Heavy Cosmic Ray Experiment (UHCRE), and lunar-based Space Exploration Initiative (SEI) science payloads. In support of future Space Physics missions, selected studies will be initiated to define mission/payload requirements, scientific feasibility, instrument/operations requirements, and programmatic issues. These studies will also include assessments of technology requirements, definition of support systems requirements, identification of long lead-time items requiring development, and assessments of cost and schedule requirements. Each mission study will include close coordination with the appropriate Science Working Groups.

W92-70350 **433-90-00**
Goddard Space Flight Center, Greenbelt, MD.
PARTICLE ASTROPHYSICS MAGNET FREE FLYER ASTROMAG
George Anikis 301-286-8416

The objective of this RTOP is to provide science support, system planning, trade-off studies and definition engineering for a free flyer spacecraft and superconducting magnet spectrometer, called the Particle Astrophysics Magnet Free Flyer Spacecraft, or Astromag. It will permit study of the properties of cosmic rays in order to understand their history as a sample of non-solar material, and their nucleosynthesis, acceleration, and transport in and effects on the galactic magnetic fields. It will also permit studies of the antiprotons observed recently in cosmic rays, and undertake antimatter searches 100 to 1000 times more sensitive than previously possible. Other investigations such as plasma physics phenomena can be studied using the large volume of high intensity magnetic field. The approach is to conduct a Phase B study leading to a cost effective spacecraft definition. The studies will be carried out by the Explorer and Attached Payloads Project Office working with the Astromag Technical Advisory Team and the Italian Space Agency. The products will be a system level design, cost and schedule, risk assessments, interface definition, and the identification of long-lead items, safety concerns and reliability approaches.

W92-70351 **433-90-00**
Goddard Space Flight Center, Greenbelt, MD.
STUDY OF THE HIGH ENERGY SOLAR PHYSICS MISSION (HESP)
Brian R. Dennis 301-286-7983

The objective of this RTOP is to study the High Energy Solar Physics (HESP) mission for implementation in time for space observations of solar flares during the next peak in solar activity at the turn of the century. The HESP payload consists of a single instrument, the High Energy Imaging SPECtrometer (HEISPEC). This one instrument is capable of obtaining X-ray and gamma-ray images of solar flares with arcsecond angular resolution and keV energy resolution from 2 keV to 20 MeV. It will also provide imaging spectroscopy of solar flare neutrons from 20 MeV to 1 GeV and moderate resolution gamma-ray spectroscopy to energies in excess of 100 MeV. It has high sensitivity and sub-second time resolution for solar flare observations. HEISPEC is based on a Fourier-transform imaging technique in which two widely spaced, fine-scale grids temporally modulate the photon signal from a source close to the axis as the individual collimators or the whole system rotates about that axis. The modulation can be measured with a detector having no spatial resolution placed behind the second grid. This is a classical rotating modulation collimator (RMC) design of the type used on previous missions such as the US SAS-C and the Japanese Hinotori spacecraft. The modulation pattern contains information on the amplitude and phase of many spatial Fourier components of the image for a finite range of source sizes. Multiple RMCs, each with different slit widths, provide coverage of different ranges of source sizes. Rotation at 15 rpm is achieved most simply by rotating the whole spacecraft. A complete image is constructed every half rotation from the measured Fourier components in exact analogy to multi-baseline radio interferometry. The use of high-purity germanium detectors (HPGe) to measure the modulation allows us to determine the spectrum with high energy resolution at the same time that the image is being determined with fine spatial resolution.

W92-70352 **433-90-00**
Goddard Space Flight Center, Greenbelt, MD.
TIMED STUDY
H. G. Mayr 301-286-7505

The objective of this RTOP is to provide system planning and conduct studies for the Thermosphere, Ionosphere and Mesosphere Energetics and Dynamics (TIMED) Mission. Issues to address are development of science objectives; measurement requirements; strawman instrument set; science driven mission requirements; spacecraft definition; spacecraft/instrument requirements; mission assessment and requirements; proposed development approach; preliminary cost/schedule requirements; and technology requirements. The approach is to conduct a pre-phase A study to be completed in FY-91 and followed by a phase A study in FY-92.

W92-70353 **433-90-00**
Goddard Space Flight Center, Greenbelt, MD.
ORBITING SOLAR LABORATORY (OSL) PHASE B
Roger A. Mattson 301-286-7751

The objective of this RTOP is to provide system planning, trade-off studies definitions and preliminary engineering design and science support for the Orbiting Solar Laboratory (OSL). The OSL is a free flying spacecraft with a 1.0 to 1.1 meter aperture telescope and is designed to carry three research instrument packages for study of the solar atmosphere.

Space Physics Sounding Rocket Research

W92-70354 **435-11-00**
Goddard Space Flight Center, Greenbelt, MD.
SOUNDING ROCKETS: SPACE PLASMA PHYSICS EXPERIMENTS
R. F. Pfaff 301-286-6328

The objective is to perform measurements and experiments that will lead to an understanding of the interactive processes that occur between neutral gases, plasmas, energetic particles, electric fields and electromagnetic waves in the atmosphere, ionosphere, and near-Earth magnetosphere. Emphasis is placed on measurements and experiments that utilize the unique characteristics of sounding rocket trajectories and/or the low cost, quick reaction sounding rocket approach which permits program flexibility. Sounding rockets provide the only access for in-situ measurements in the lower ionosphere (altitudes below 200 km) and middle atmosphere regions (30 to 90 km). Historically, this approach has logically been extended to include sounding rocket experiments at remote sites of keen geophysical importance (e.g., the dip equator or the auroral zone); experiments involving sounding

rocket flights in association with simultaneous satellite measurements; flight testing of new instrumentation and measurement techniques; and investigations of the electrodynamics of middle atmosphere (i.e., below 90 km), including experiments that deploy special payloads such as those that descend via parachutes. The individual programs supported by this RTOP have traditionally involved extensive collaborations with other U.S. and European scientific groups and facilities, and international campaigns.

Spacelab Payload Instrument Development/Astrophysics

W92-70355 **440-62-59**
Goddard Space Flight Center, Greenbelt, MD.
TEMPORAL X-RAY ASTRONOMY
Richard Kelley 301-286-7266

The sky is filled with thousands of celestial X-ray sources that have time-variable X-ray intensities. Studies of these variations have contributed greatly to our knowledge of the nature and environment around neutron stars, white dwarfs, and possibly black holes. These objects are generally members of close binary systems in our galaxy, but others are believed to be highly massive black hole systems at the centers of distant active galaxies. Observations of periodicities provide information on orbital and precession periods, which in turn lead to mass estimates. Non-periodic variability can also lead to estimates of dimensions, which, when combined with X-ray luminosity estimates, also provide mass and system geometry information. In some cases, transient X-ray outbursts are the key signature to the existence to black holes. The goal and approach of this RTOP is to study these rare X-ray systems using continuous monitoring techniques over the range 1 to 20 keV. Such techniques include pin-hole X-ray cameras and coded aperture devices on spacecraft that orbit for periods of years. Such devices provide two important functions. One is to monitor the X-ray sky for transient X-ray outbursts from new and previously known sources in order to alert more powerful optical X-ray spectrometers, and the other is to provide long-term records of these objects which provide dynamical information.

W92-70356 **440-62-59**
Goddard Space Flight Center, Greenbelt, MD.
X-RAY MULTI-MIRROR MISSION (XMM) REFLECTION GRATING SPECTOMETER
G. W. Ousley, Sr. 301-286-8073
(689-46-59)

The purpose of this RTOP is to fabricate and test the prototype tooling for the Reflection Grating Module (RGM) assembly machine. Other goals are to use the results of the EOM assembly, to complete the design of the Flight assembly hardware, to replicate prototype gratings for the EOM, to complete the testing and evaluation of the EOM substrates, to determine if they can maintain the desired degree of flatness, and to complete the fabrication of the EOM. The Design Study to date has resulted in a change in the approach for the fabrication of the substrates and in the method of assembling and aligning the gratings in the RGM. This approach has resulted in the design of an RGM assembly machine which should make the assembly and alignment of the gratings less complex and more precise. Tests will continue on the sample gratings and replications to determine which method to use for the flight RGS. The various substrates will be tested and evaluated and selection made. The EOM will be assembled using the new tooling. The testing and evaluation of the EOM will begin.

W92-70357 **440-62-59**
Goddard Space Flight Center, Greenbelt, MD.
XMM OPTICAL MONITOR (OM) DIGITAL PROCESSING UNIT
G. W. Ousley, Sr. 301-286-6701
(689-46-59)

The purpose of this RTOP is to complete the definition studies and design of the Digital Processing Unit (DPU) necessary to compress the XMM Optical Monitor (OM) data from the expected count rates (up to 10x5 counts/s) so it can fit into the telemetry bandwidth available, to update and refine the software developed to meet the degree of compression required, and to develop a functional model of the OM. The design will be based on similar designs currently under development for other flight programs.

W92-70358 **440-62-59**
Marshall Space Flight Center, Huntsville, AL.
SPECTRUM X-GAMMA (SXG) POLARIMETER
M. C. Weisskopf 205-544-7740

The objective of this RTOP is to conduct research in cosmic x-ray polarimetry in areas related to the Astrophysics programs of NASA, in particular the Stellar X-Ray Polarimeter for Spectrum X-Gamma. Other objectives are to provide computer simulation support for the design, development, and construction of the Stellar X-Ray Polarimeter for Spectrum X-Gamma; to provide data analysis support for the Stellar X-Ray Polarimeter; and to provide support to the environmental testing of engineering and flight hardware.

W92-70359 **440-62-59**
Goddard Space Flight Center, Greenbelt, MD.
SATELITE DE APLICACIONES CIENTIFICAS (SAC-B)
G. W. Ousley, Sr. 301-286-8073
(188-46-57)

The objective of this RTOP is to conduct studies at GSFC and Pennsylvania State University to develop an integrated instrument complement (3 instruments) to make X-Ray, and UV measurements of the entire sky utilizing an Argentine spacecraft. The studies and design effort will be based on using existing instrument designs currently under development for other flight projects.

W92-70360 **440-63-25**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
ORBITING VERY LONG BASELINE INTERFEROMETRY (OVLBI)
J. G. Smith 818-354-6584

The objective of this RTOP is the development of scientific goals and advantages of Space VLBI, and development of plans for appropriate participation of the U.S. in international Space VLBI missions. The Japanese have selected a Space VLBI mission, the VLBI Space Observatory Program (VSOP), for launch in January 1995. The Soviets have selected a Space VLBI mission, RADIOASTRON, for launch also in January 1995. Both the Japanese and the Soviets have expressed interest in U.S. participation in their missions. This RTOP will support U.S. role definition and support to the Astrophysics Division in the negotiations with the Japanese and the Soviets for U.S. participation.

W92-70361 **440-63-44**
Ames Research Center, Moffett Field, CA.
THE DEVELOPMENT OF A MID-INFRARED SPECTROMETER FOR THE INFRARED TELESCOPE IN SPACE
T. L. Roellig 415-604-6426

The objective of this RTOP is to develop and construct a Mid-Infrared Spectrometer (MIRS) for the Infrared Telescope in Space (IRTS). The IRTS is a Japanese telescope that will be launched by a Japanese expendable launch vehicle in 1994. The MIRS is a joint development project between NASA and the University of Tokyo. The spectrometer will have a wavelength coverage ranging from 4.2 to 11.3 microns and will be designed for astronomical studies of diffuse infrared sources. The approach of this RTOP is to divide the technical development between NASA Ames and the University of Tokyo. The instrument will be

assembled at Ames, tested, and then installed in the Japanese spacecraft. The data will be shared equally between NASA Ames and the University of Tokyo for a proprietary period before release to the general astronomical community.

Origins of Solar Dynamics

W92-70362 **452-11-93**
Ames Research Center, Moffett Field, CA.
INFRARED STUDIES OF PLANETARY DEBRIS AROUND YOUNG MAIN SEQUENCE STARS
F. C. Witteborn 415-604-5520

The objective of this RTOP is a comprehensive search for evidence of planet formation near young main sequence stars, focusing on the infrared signature of collisional debris associated with planetary accretion. Significant infrared excess is expected if as little as 1 percent of the planetary mass remains in an asteroid-micrometeoroid size distribution. Our targets are nearby stars with ages known to lie between 0.01 and 1Byr, plus older stars for comparison. The main goals of our program are an understanding of the variation of continuum flux excesses and spectral features diagnostic of solid circumstellar grains as a function of stellar age, and a determination of the fraction of young main sequence stars that have such circumstellar grains. The approach of the RTOP is planned observations consisting of broadband infrared photometric surveys of field and cluster stars, combining ground-based data with IRAS data, to be followed by spectroscopy of stars found to have significant thermal infrared excesses. The shape and strength of continuum excesses deduced from the photometry can be used to derive temperature (distance from star) and amount of circumstellar material. The identity and strength of spectral features can be used to characterize the particle composition sizes and collisional history. Planned theoretical work consists of models of grain spectra characteristic of collisionally altered material to be compared with spectra of material around candidate stars, and a rigorous study of stellar age indicators, allowing expansion of the sample of young stars for our observational program to include numerous and nearby field stars.

W92-70363 **452-21-93**
Ames Research Center, Moffett Field, CA.
PLANET-FORMING DISKS
P. Cassen 415-604-5597

The objective of this RTOP is to develop a predictive theory of the formation of protostellar disks and their physical and chemical evolution, and to relate these to the history of the primitive solar nebula. The approach used is to generate mathematical models of the physical processes that control interstellar cloud collapse, disk formation and disk dynamical evolution; derive the consequences of the modeled processes for the processing of interstellar material; and test the results by comparison with solar system data derived from the examination of primitive material.

W92-70364 **452-22-93**
Ames Research Center, Moffett Field, CA.
TWO-PHASE NEBULAE
J. Cuzzi 415-604-6343
(151-01-60; 151-01-08)

The objective of this RTOP is to contribute to the understanding of the origin of the planets of the solar system, one of NASA's most fundamental goals. Research is focused on modeling the accretion of particulates in the size range sampled by meteorites (microns to meters in particle radius) within a turbulent layer near the nebula midplane in which the dynamical influence of the particle and gas phases on each other is substantial leading to a strongly coupled behavior of the system as a whole. The results obtained are of both immediate and long-term value to NASA in guiding extraterrestrial sample analysis (meteorites, interplanetary dust particles (IDPs), Mars samples, comet nucleus samples) and astrophysical observations of extrasolar particle disks (Hubble Space Telescope (HST), Stratospheric Observatory for Infrared Astronomy (SOFIA), Space Infrared Telescope Facility (SIRTF)). The approach of this RTOP is to use theoretical modeling of the two-phase fluid dynamics of the particle-gas system to provide mean and turbulent flow states in which to implement particle coagulation calculations. Our coagulation calculations will incorporate theoretical studies of grain sticking for a variety of particle compositions (water, silicate, organic) and configurations (solid, fractal, and composite). Coagulation determines the evolution of the particle size distribution which will feed back into the fluid dynamics to influence the generation and damping of mean flows and turbulence. Ultimately radiative transfer, energetics, and simple chemical mixing will be incorporated in a self-consistent fashion.

W92-70365 **452-23-94**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
ORIGINS OF SOLAR SYSTEMS
J. F. Appleby 818-354-3943

This group of research tasks addresses a range of modeling and simulation problems concerning the origins of solar systems. Specifically, characteristic features of the planetary accretion process are investigated, including density wave propagation during disk-planet interactions and a search for features that distinguish circumstellar disks containing protoplanetary objects. Models are developed for the dynamics of cometary Oort clouds around field stars orbiting the galaxy within a realistic, changing dynamical environment. This study will elucidate possible structures for these comet clouds and, consequently, their detectability, with possible inferences for the existence of unresolved planets closer to the central star. Chemical models will be examined for the dense star-forming fragments of interstellar gas-and-dust clouds. The physical and chemical conditions of such regions may help to explain the observed chemical abundances in our solar system and the origin of comets. The approach makes use of theoretical models of density wave disturbances in the study of planetary accretion processes, including a study of resonant trapping of planetsimals. Cometary Oort cloud perturbations are modeled using a computer-based simulation of the galactic dynamical environment. Finally, the approach includes the use of computer code of time-dependent interstellar ion-molecule chemistry.

W92-70366 **452-33-93**
Ames Research Center, Moffett Field, CA.
CHEMICAL EVOLUTION OF INTERSTELLAR ICES: THE CONNECTION WITH PRIMITIVE SOLAR SYSTEM MATERIALS
L. J. Allamandola 415-604-6890

The objective of this RTOP is to increase our knowledge of chemical evolution and deuterium fractionation in interstellar ices and comets. These processes determine the raw material from which the solar system formed and are the link between organic matter in the solar system, comets, and meteorites. The approach of the RTOP is to prepare interstellar ice analogs and complex organic molecules in the laboratory under conditions simulating those in space. Their spectroscopic properties will be studied as part of the analysis of the materials produced by energetic processing. These materials will also be analyzed chemically to determine which specific compounds are made. Transmission electron micrography will be made of the ices to determine the microscopic structure of the ice in order to understand how these structures mediate macroscopic behavior including gas release from comets.

W92-70367 **452-89-91**
Goddard Space Flight Center, Greenbelt, MD.
MANAGEMENT SUPPORT: ORIGINS OF SOLAR SYSTEMS RESEARCH PROGRAM
J. Nuth 301-286-9467

The purpose of this RTOP is to support the requirements of the Discipline Scientist for the Origins of Solar Systems Research

Program at Goddard Space Flight Center (GSFC). NASA Headquarters provides the funds necessary to support the operations of the NASA Origins of Solar Systems Research Program Discipline Scientist at GSFC. Specifically, this provides money for support of a part-time scientific typist and data entry technician to prepare the procurement paperwork necessary to initiate NASA funding (through NASA Headquarters) for researchers selected through the Origins of Solar Systems NRA. This contractor provides up-to-date accounting information to the Discipline Scientist and types all correspondence and reports from the Discipline Scientist to both NASA Headquarters and the scientific community. This RTOP also provides the funds necessary to hire a part-time laboratory technician who handles some of the more routine laboratory experiments and equipment maintenance for the Discipline Scientist in recognition of the time spent by the Discipline Scientist in the day-to-day management of the Origins of Solar Systems Research Program for NASA Headquarters.

Laser Research Facilities

W92-70368 **453-21-30**
Goddard Space Flight Center, Greenbelt, MD.
CRUSTAL DYNAMICS SATELLITE LASER RANGING
H. G. Linder 301-286-2052
(465-21-10; 579-32-06)

The scientific objectives are to improve the knowledge and understanding of regional deformation and strain accumulation related to large earthquakes in the plate boundary regions in western North America; contemporary relative motions of the North American, Pacific, South American, Nazca, Eurasian, and Australian Plates; internal deformation of continental and oceanic lithospheric plates, with particular emphasis on North America and the Pacific; rotational dynamics of the earth and their possible correlation with earthquakes, plate motions, and other geophysical phenomena; and regional deformation in other areas of high earthquake activity. In order to achieve these objectives, an extensive measurement program utilizing Satellite Laser Ranging (SLR) is underway. Frequent high-accuracy measurements of baselines between many stations in active areas near plate boundaries are being made to determine regional deformation and strain accumulation. Baselines between a global set of stations are being measured repeatedly to determine relative plate motions. Repeated measurements of baselines between several stations on the same plate are being made to determine the internal deformation of the plate. Polar motion and Earth-rotation variations are derived from daily measurements with a global set of stations in stable locations.

W92-70369 **453-21-40**
Goddard Space Flight Center, Greenbelt, MD.
LAGEOS II (INTERNATIONAL COOPERATIVE PROJECT)
G. W. Ousley, Sr. 301-286-8073
(693-00-00)

The objective of this RTOP is to provide a cooperative U.S./Italian spacecraft to be used by the Crustal Dynamics project. (A NASA LAGEOS was launched in 1976.) The approach is based on a Memorandum of Understanding between NASA and Italy. Italy will provide the spacecraft, upper stage, and apogee kick motor. NASA will provide a launch on the Space Transportation System (STS), laser tracking of the satellite, and laser optical characterization of the satellite.

Radiation and Dynamic Processes

W92-70370 **460-20-00**
Goddard Space Flight Center, Greenbelt, MD.
MICROWAVE REMOTE SENSING
James A. Weinman 301-286-3175

Microwave remote sensing technology and analysis will be improved and developed by members of the GSFC staff and colleagues at universities. This RTOP also needs support for support staff and test and maintenance equipment required to support airborne tests.

W92-70371 **460-20-00**
Marshall Space Flight Center, Huntsville, AL.
PROCESS STUDIES: RADIATION DYNAMICS AND HYDROLOGY, RADIATION AND DYNAMIC PROCESSES
R. J. Koczor 205-544-3078

The objective is to perform a series of studies to assess current remote sensing capabilities to study earth processes, develop aircraft-based prototype instruments to test future remote sensing concepts, derive relevant geophysical parameters from these aircraft and space-based sensors which contribute to describing the radiational and dynamical processes associated with the earth system. The approaches utilize the talents of university and private contractor groups to assist in-house engineers in the development of aircraft remote sensing systems, utilize in-house expertise to assess these measurements and derive the necessary geophysical parameters to describe the earth system.

W92-70372 **460-20-00**
Langley Research Center, Hampton, VA.
RADIATION AND DYNAMICS PROCESSES
M. P. McCormick 804-864-2669

The objective of this RTOP is to develop advanced techniques for the measurement of tropospheric aerosols, clouds, winds, and water vapor important to understanding radiative, meteorological, and dynamical processes. The approaches for achieving these objectives consist of: (1) the development and refinement of Differential Absorption Lidar (DIAL) concepts and systems in the near IR-region (near 0.727, 0.820, and 0.94 microns) for water vapor measurements; and (2) the utilization of SAGE I and II, and SAM II aerosol data for developing a global climatology, and the use of these data for understanding backscatter at wavelengths to be used by spaceborne Doppler lidar wind measuring systems.

W92-70373 **460-21-00**
Goddard Space Flight Center, Greenbelt, MD.
ATMOSPHERIC STRUCTURE AND DYNAMICAL STUDIES
S. H. Melfi 301-286-7024

The objectives are to understand and measure the dynamics of the atmosphere during rapidly changing conditions and when subject to turbulent conditions, such as the passage of warm and cold fronts, the development of storms, and the activity of gravity waves. High spatial and temporal resolution measurements of atmospheric moisture and aerosol profiles and the transport of heat, momentum, and water vapor through the planetary boundary layer will be studied through the analysis of airborne lidar data. Improvements to the lidar instrumentation will be made in the existing data system and scanning system. Analysis of existing lidar data sets will continue to determine meteorological significance and to gauge engineering performance. Data will be acquired before and during field campaigns.

W92-70374 **460-21-81**
Ames Research Center, Moffett Field, CA.
CO2 LIDAR BACKSCATTER EXPERIMENT
R. F. Pueschel 415-604-5254

The objective is to measure aerosol size distributions and particle shapes and composition simultaneously with the CO2 lidar measurements as a means of validating the lidars which will be precursors to the Doppler lidars planned for wind measurements from space (LAWS-Laser Atmospheric Wind Sounder). The

approach is to fly impactors and laser aerosol spectrometers on the Ames DC-8 aircraft to measure the global variability in aerosol size distributions and particle characteristics. These measurements will contribute data needed for lidar backscatter calculations to assess the sensitivity of CO2 lidar for wind velocity measurements. Emphasis in FY-92 will be a thorough analysis and publication of data collected in GLOBE I and II mission flights, and participation in GLOBE III.

W92-70375 **460-22-00**
Wallops Flight Facility, Wallops Island, VA.
IN SITU/REMOTE INSTRUMENT ANALYSIS AND VERIFICATION
F. J. Schmidlin 804-824-1618

The objective is to improve upper-atmosphere measurement capability. In situ temperature measurements are important since they provide the basic measurements for ground truth of satellites and other instrumentation. Enhance the existing knowledge of upper-air instrument precision and accuracy. Investigate performance and behavior of radiosondes. Initiate use of the three-thermistor technique, developed to produce temperature sensor corrections, as a reference temperature standard. More accurate temperature sensing is sought after, therefore, initial use of the three-thermistor reference system will be used to intercompare against systems that have had long-time usage and against a newer instrument that uses a small-diameter (approx. 0.05 mm) thermocouple. Thermocouple technology is expected to provide rapid responding, highly accurate measurements. Compare satellite (TOVS) and radiosonde data over a spectrum of atmospheric wavelengths; deduce retrieval algorithm coefficient errors resulting from errors of radiosonde temperatures. Temperature corrections developed for the U.S. standard radiosonde's sensor have been extended to other sensor designs and are currently in use at NMC. This technique will be offered to the ECMWF. Investigate and improve sensor capability to obtain relative humidity measurements with and accuracy of 3 to 5 percent. The approaches are to: (1) provide the expertise to test and evaluate various radiosonde systems and techniques using the unique telemetry, radar and computing capability located at GSFC/Wallops Flight Facility; and (2) improve the newly developed temperature corrections for the rod thermistor of the U.S. standard radiosonde and up-date adjustments developed for those instruments compared in the WMO International Radiosonde Intercomparison.

W92-70376 **460-22-51**
Goddard Space Flight Center, Greenbelt, MD.
AEROSOL SCATTERING CROSS SECTIONS
S. H. Melfi 301-286-7024

The objective is to provide visible and near-infrared backscatter measurements for the Global Aerosol Backscatter Experiment (GLOBE), which, in turn, provides data for the feasibility of space-based lidar wind sensing. Basic processing and archival of data from the GLOBE program will be completed. Overall statistics of the measurement results will be developed, and intercomparison between lidar and in situ particle measurements will be studied.

W92-70377 **460-22-52**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
LIDAR TARGET CALIBRATION FACILITY
R. T. Menzies 818-354-3787
(460-22-53; 460-28-41)

The primary objective of the JPL Lidar Target Calibration Facility is to provide accurate and consistent calibration of CO2 lidar targets. Customers in the lidar community will each provide a sample to JPL of the target surface which is to be used to calibrate the customer's lidar system. Parameters which are used in the lidar calibration, such as the CO2 laser wavelength, incident and reflected polarizations, and the polar angle at the target will be specified by the customer. The measurement result provided to the customer for each set of specified parameters will be the target reflectance parameter, which is used in the reduction of hard target and aerosol backscatter data to obtain the desired profile of the aerosol backscatter coefficient. The calibration methodology to be used will strive for maximum measurement continuity and accuracy between an integrating sphere measurement of a lambertian primary standard, a backscatter reflectance ratio measurement of the customer's target to the primary standard, and the eventual field use of the customer's target to calibrate a lidar system. Accuracy will be achieved through careful experimental techniques such as incorporating spinning targets to reduce special effects.

W92-70378 **460-22-53**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
ATMOSPHERIC BACKSCATTER EXPERIMENT
R. T. Menzies 818-354-3787
(460-22-52; 460-28-41)

The objective of this program is to support studies of the feasibility and scientific value of an Earth-orbiting Doppler lidar for global-scale tropospheric wind measurements, by the direct measurement of tropospheric aerosol backscatter coefficients at wavelengths in the 9 to 11 microns range over large geographical regions, emphasizing those regions which are important in the global winds measurement studies but difficult to characterize at present due to the scarcity of aerosol measurement data. The use of range-gated lidar to obtain altitude profiles of aerosol backscatter coefficients is an efficient means of sampling the troposphere at carefully selected times. This investigation consists of flights of an airborne CO2 lidar on the NASA DC-8 research aircraft, configured to measure vertical profiles of aerosol backscatter from the aircraft altitude (near the tropopause) to the surface or above the aircraft altitude. The lidar is flown on the NASA DC-8 on several missions over the Pacific Ocean, including Southern Hemisphere measurements. The data obtained are analyzed and considered in the context of related instrument measurements of atmospheric aerosols, cloud cover statistics, and other atmospheric parameters.

W92-70379 **460-23-47**
Goddard Inst. for Space Studies, New York, NY.
TURBULENT PLANETARY BOUNDARY LAYER
Vittorio M. Canuto 212-678-5571

The method we propose to study the PBL has several advantages of both a methodological and practical nature. From the methodological point of view, it separates the problem into two phases. First, one determines the source function omega(k) that characterizes the rate at which energy is injected into the system. The function omega(k) is derived using a primary instability analysis and/or a secondary instability analysis, where the latter yields results in closer agreement with experimental data than the former. The principles to be followed are clear and the methodology is well-established. Mean flow, convection, rotation, etc., can all be included for arbitrary values of R, Ra, E(sub k), etc. It is important to emphasize that this phase of the problem contains no free, adjustable parameters. Second, one employs the most reliable and flexible model presently available, the EDQNM model, to model the non-linear interactions among the eddies that distribute the energy injected into the system at a rate given by omega(k). The result is the turbulent energy spectrum E(k), the shape of which clearly depends upon the values of R, Ra, E(sub k), etc. The function E(k) is one of the most fundamental quantities of turbulence since it allows, together with omega(k), the computation of quantities of direct interest such as turbulent kinetic energies, turbulent viscosities, turbulent convective fluxes, etc. As in the determination of omega(k), this second phase does not require any free, adjustable parameters.

W92-70380 **460-25-21**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
IR REMOTE SENSING OF SST: BALLOON MEASUREMENTS
D. E. Hagan 818-354-7073
(460-21-28)

This RTOP provides supplementary funds to related RTOP 460-21-28, the objectives of which are to investigate and to improve infrared methods of measuring sea surface temperatures (SST)

from space. The proposed experimental work will study the sensitivity of radiometric measurements of the upwelled surface radiation when the ocean is observed through a germanium aircraft window. The approach is to make vertical path measurements of the outgoing sea surface radiation in the atmospheric window spectral region (10 to 12 microns) using a high precision radiometer flown from a LTA platform.

W92-70381 **460-26-00**
Goddard Space Flight Center, Greenbelt, MD.
SCIENTIFIC PROGRAM SUPPORT AND SUPPORT FOR THE HIGH SPEED VECTOR PROCESSOR AND AOIPS DEVELOPMENT
Franco Einaudi 301-286-6786

The objective is to: (1) provide funding for support activities of benefit to the Severe Storms Branch as a whole and for the use of the high speed vector processor; and (2) provide funding for AOIPS software development.

W92-70382 **460-26-00**
Goddard Space Flight Center, Greenbelt, MD.
PROGRAM SUPPORT
S. H. Melfi 301-286-7024

The objective is to provide program support for the GSFC Environmental Sensors Branch, Code 917.

W92-70383 **460-28-41**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
WIND MEASUREMENT ASSESSMENT
R. T. Menzies 818-354-3787
(460-22-52; 460-22-53)

The objective of this program is to evaluate certain aspects of the Doppler lidar technique for global measurement of tropospheric wind fields. This technique has the potential for providing global wind data from an orbiting platform. Several types of remote measurement of atmospheric wind velocities have been analyzed; e.g., passive microwave, millimeter wave, infrared radiometry, and active visible and infrared range-rated lidar, with the results indicating that the infrared Doppler lidar technique is the superior technique for tropospheric wind field measurements. During FY-92, the work will continue to add to the climatology of aerosol backscatter by further experimental study of vertical profiles of backscatter at CO2 laser wavelengths in the 9 to 11 microns region. An emphasis will also be placed on assessing the influence of visible and sub-visible cirrus on the backscatter to be expected, including seasonal dependence of probability of occurrence. This study is being conducted using an existing TEA CO2 lidar facility, employing as single-longitudinal-mode (SLM) injection-controlled TEA laser transmitter and a heterodyne receiver. During FY-92 the development of a solid-state 2-microns lidar will begin, with the objective being the future collection of backscatter profiles at this wavelength as well, to assess seasonal and long-term trend effects. The use of air parcel trajectory analysis capabilities at UCLA will be continued in order to study the dependence of aerosol backscatter on the history of the air parcel. Comparative performance analysis of the major types of Doppler lidar, including both incoherent and coherent detection, have been conducted and reported in the literature. These studies will be re-assessed as new data and new technology become available.

W92-70384 **460-40-00**
Langley Research Center, Hampton, VA.
RADIATION AND DYNAMICS PROCESSES
Edwin F. Harrison 804-864-5663

The objective is to conduct regional studies of aerosols, water vapor, clouds, and radiation processes which are the key to the improvement of parameterizations needed for climate models. The following approach will be used: (1) the continuation of 48-inch ground-based Lidar measurements to extend the climatology of aerosol distributions and cloud measurements in support of the First International Satellite Cloud Climatology Regional Experiment (FIRE) and ECLIPS Program; (2) the analysis of satellite data (Geostationary Operational Environment Satellites (GOES), LANDSAT, and Advanced Very High Resolution Radiometer (AVHRR)) and surface observations to define spatial seasonal, and diurnal variation of cloud radiative properties as part of the FIRE investigations; (3) the combination of satellite, surface, and airborne measurements with theoretical studies to investigate cirrus and marine stratocumulus cloud systems for FIRE; and (4) the conducting of scientific activities associated with LITE instrument development, flight implementation, data validation, and data use for the first LITE mission.

W92-70385 **460-41-25**
Goddard Space Flight Center, Greenbelt, MD.
RADIATION AND DYNAMICS PROCESSES
Albert Arking 301-286-7208

The objective of this RTOP is to determine the radiative and optical properties of marine and arctic stratus clouds from airborne measurements above, below, and within clouds. The approach is to observe and analyze data from aircraft field measurements.

W92-70386 **460-42-00**
Goddard Space Flight Center, Greenbelt, MD.
RADIATION AND DYNAMICS PROCESSES
Albert Arking 301-286-7208

The objectives of this RTOP are to: (1) determine the radiative properties of cirrus and marine stratus clouds and their influence on earth's climate; (2) simulate cloud fields with observed fractal properties; and (3) provide laboratory calibration of atmospheric and aerosol remote sensing measurements. The approach is to: (1) examine the structure, radiative properties of cirrus and marine stratus based on data from FIRE and related meteorological observations; (2) develop numerical model for cirrus cloud; and (3) conduct experiments to verify and yield reliable absolute radiance scales used as laboratory standards.

W92-70387 **460-42-00**
Ames Research Center, Moffett Field, CA.
RADIATIVE EFFECTS IN CLOUDS FIRST INTERNATIONAL SATELLITE CLOUD CLIMATOLOGY REGIONAL EXPT.
F. P. J. Valero 415-604-5510

The objective is to gain an understanding of the interaction of radiation and clouds through the measurement and modeling of the interaction of radiation and clouds including: radiative flux divergence profiles; optical depths; total/diffuse radiation fields; and particle size distributions in stratus and cirrus clouds. It is a fundamental objective of this work to validate satellite-acquired radiative data. Measurements will be made using aircraft as instrument platforms during the First International Satellite Cloud Climatology Regional Experiment (FIRE) deployments. From the above measurements, the significant radiative energy parameters are determined and used in radiative transfer modeling to validate model prediction.

W92-70388 **460-42-59**
Goddard Space Flight Center, Greenbelt, MD.
RADIATION, CALIBRATION, VALIDATE, AND FIELD STUDY
J. R. Bates 301-286-7482

This study is developing, improving, and verifying physical algorithms to derive radiation budgets using satellite data. This year satellite data was verified and the agreement was good. Next year, the First International Satellite Cloud Climatology Regional Experiment (FIRE) data will be employed in the verification studies.

W92-70389 **460-43-00**
Ames Research Center, Moffett Field, CA.
AEROSOL FORMATION MODELS
O. B. Toon 415-604-5971
(672-32-99)

The objective of the work is to gain a better understanding of water clouds and their effects on the radiation balance. A three-dimensional tracer transport model has been developed. A radiation code suitable for use in multi-dimensional models has been developed. A model of cirrus cloud microphysics has been

developed. A microphysical model of marine stratus clouds has been developed. Also a model of tropospheric cloud condensation nuclei physics and chemistry is being developed for use in exploring cloud formation processes and their impact on cloud radiative properties.

W92-70390 **460-43-45**
Goddard Space Flight Center, Greenbelt, MD.
RADIATION AND DYNAMICS PROCESSES
Albert Arking 301-286-7208

The objectives of this RTOP are to: (1) study the effect of aerosols on clouds with satellite data; and (2) detect climate changes from remote sensing of spatially and temporally intermittent phenomena such as rain and clouds. The approach is to: (1) validate results with in situ aircraft measurements of aerosol and cloud properties; and (2) develop statistical methods to make better use of existing data in combination with low orbit satellites for optimal detection of climate signals.

W92-70391 **460-44-40**
Goddard Space Flight Center, Greenbelt, MD.
RADIATION RETRIEVAL ALGORITHMS
J. R. Bates 301-286-7482

The objective is to measure the instantaneous rainfall rate. A statistical method will be needed to integrate the instantaneous rainfall amounts. An absorption technique that is applicable over oceans has been studied extensively and will be used to retrieve rainfall amounts. Monthly rainfall indices over the oceans will be derived by statistically matching the observed histograms with model calculated rainfall probability distribution function using 19 and 22 GHz data. Derived rainfall maps of 1987, 1988, and 1989 will be examined to determine the areas of improvement.

W92-70392 **460-44-42**
Goddard Space Flight Center, Greenbelt, MD.
RADIATION AND DYNAMICS PROCESSES
Albert Arking 301-286-7208

The objectives of this RTOP are to: (1) understand physical reasons and resolve large disagreement between state-of-the-art atmospheric radiation models for general purpose radiation computations for climate applications; and (2) study radiative properties at the earth surface from satellite measurements. The approach is to: (1) carry out field program SPECTRE (Spectral Radiance Experiment) in conjunction with the First International Satellite Cloud Climatology Regional Experiment (FIRE); (2) verify surface radiation components derived from satellite against ground truth data; and (3) analyze and understand the effect of radiative heat flux for regional climate applications using Earth Radiation Budget Experiment (ERBE) and International Satellite Cloud Climatology Project (ISCCP) data.

W92-70393 **460-45-00**
Goddard Space Flight Center, Greenbelt, MD.
SOLAR RADIUS LUMINOSITY
R. E. Hartle 301-286-8234

The Yale/GSFC team will study the climate impact of solar variability using the main approach of combining solid theoretical work with ground-based truth (i.e., from experiments). From basic physical principles, it can be shown that a solar diameter change affects the solar luminosity. Thus, the main experimental thrust is to develop a Solar Disk Sextant (SDS) to measure the changing radius of the sun. Additional theoretical work areas are on the influences of magnetic fields on convection and vice versa.

W92-70394 **460-47-00**
Ames Research Center, Moffett Field, CA.
MULTIDIMENSIONAL STUDIES OF TROPOSPHERIC CLOUDS
D. L. Westphal 415-604-3522

The objectives of this work are: (1) to study the atmospheric structure, dynamics, and cloud fields during the First International Satellite Cloud Climatology Project Regional Experiment (FIRE) cirrus field programs; and (2) to develop parameterizations of clouds and their radiative effects for use in mesoscale models and to validate these parameterizations using measurements made during the Cirrus Intensive Field Observation periods. The approach is to couple numerical models of atmospheric dynamics, cirrus cloud microphysics, and radiative heat transfer to form a unique forecast model capable of simulating observed midlatitude weather systems. These model simulations will be compared with observations and evaluate the ability of the model to simulate the observed cloud fields, radiative fluxes, and the net radiative budget for the domain. Improvements to the model's cloud parameterization will be developed, tested, and validated using data from the Cirrus Intensive Field Observation periods.

W92-70395 **460-48-20**
Goddard Space Flight Center, Greenbelt, MD.
CLOUD TOP REMOTE SENSING STUDIES
S. H. Melfi 301-286-7024

The objectives of this RTOP are to develop and test prototype instruments which employ advanced aerial array detectors for high spatial resolution rapid time sequence cloud imagery and cloud bidirectional reflection measurements. The oxygen A-band technique will be studied with existing NASA ER-2 aircraft observations. Data analysis and image processing hardware and techniques will be developed.

W92-70396 **460-98-00**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
GEWEX SUPPORT
D. G. Vane 818-354-3708

The objective of this RTOP is to provide support to the NASA Global Change Program in: (1) developing the Global Energy and Water Cycle Experiment (GEWEX) for NASA; (2) planning for the GEWEX Continental-Scale International Project (GCIP); (3) coordinating GCIP and GEWEX plans with the National Oceanic and Atmospheric Administration (NOAA) and other agencies; and (4) planning and conducting a GEWEX Guest Lecture Series at JPL.

Hydrologic Processes

W92-70397 **461-10-00**
Marshall Space Flight Center, Huntsville, AL.
HYDROLOGIC PROCESSES, FIELD STUDY
G. S. Wilson 205-544-1628

The objective of this RTOP is to contribute to the NASA Hydrologic Processes, Field Study Program by conducting applied research and development activities using space-related techniques and observations that will increase the basic understanding of the earth's hydrologic cycle. Utiiizing the talents of university and private contractor groups, plus the MSFC in-house talents and laboratory capabilities, specific research activities as described in the tasks of this RTOP will be accomplished.

W92-70398 **461-13-00**
Goddard Space Flight Center, Greenbelt, MD.
ENERGY BALANCE APPROACH TO SNOWMELT RUNOFF MODELING USING REMOTELY SENSED DATA
A. T. C. Chang 301-286-8997

The objective of this RTOP is to improve the present technique for determining the snow covered area and snow water equivalent using co-located visible, near infrared, infrared, and microwave measurements from satellites. Nimbus-7 Scanning Multichannel Microwave Radiometer (SMMR) derived monthly snow storage maps have been produced for the period of November 1978 to July 1987. The passive microwave algorithms need to be tuned to account for changes in topography, elevation, forest cover, and snow grain size in different geographic areas. Visible, infrared, and microwave data will be used in a combined snow retrieval

algorithm to take advantage of different types of data. To quantify the accuracy of derived areal snow parameters, stream flows derived from energy balance driven snowmelt runoff models will be compared to the measured stream flow from selected watersheds.

W92-70399 **461-13-01**
Goddard Space Flight Center, Greenbelt, MD.
MODELING AND MULTISPECTRAL SATELLITE DATA ANALYSIS FOR LAND SURFACE STUDY WITH SPECIAL EMPHASIS ON HOT ARID AND SEMI-ARID REGIONS
Bhaskar J. Choudhury 301-286-5155
(579-42-02)

The objectives of this RTOP are: (1) to quantify seasonal and inter-annual variations of surface wetness, temperature, microwave polarization difference and spectral vegetation indices over hot arid and semi-arid regions of northern Africa and southeastern Australia for the period 1979 to 1988 using Scanning Multichannel Microwave Radiometer (SMMR), Advanced Very High Resolution Radiometer (AVHRR), Thematic Mapper (TM), and Special Sensor Microwave/Imager (SSM/I) data; and (2) to perform radiative transfer and heat balance simulations to understand this data in terms of land surface prognostic and diagnostic variables. A predictive model for surface wetness will be developed based upon SMMR 6.6 and 37 GHz data and tested over an independent region within the U.S. Southern Great Plains. Then the SMMR data will be used to produce soil moisture maps for northern Africa and southeastern Australia for 1979 to 1987. Radiative transfer and heat balance models will be used with hourly meteorologic data acquired from the National Climate Center to simulate reflectances, vegetation indices, and surface temperature. The simulated relations between the multispectral data will be compared with the observed relations to evaluate the relative sensitivity to varied surface and environmental characteristics.

W92-70400 **461-13-80**
Goddard Space Flight Center, Greenbelt, MD.
MOISTURE DATA ASSIMILATION
Franco Einaudi 301-286-6786

The objective of this RTOP is to understand the dynamics of tropical and extratropical cyclones over oceanic regions. The approach is to: (1) use a combination of Special Sensor Microwave/Imager (SSM/I) and Geostationary Operational Environment Satellites (GOES)/Infrared (IR) data to obtain precipitation rates; (2) enhance initial moisture data; and (3) test in 2-D and 3-D models and perform simulations to compare cases with and without explicit moisture scheme.

W92-70401 **461-16-00**
Goddard Space Flight Center, Greenbelt, MD.
HYDROLOGY PROGRAM SUPPORT
Edwin T. Engman 301-286-5480

The objective of this RTOP is to provide funding for support activities of benefit to the branch as a whole without impacting other elements of the GSFC Hydrology program. It provides funding for the scientific visitor program through a university contract and administrative support related to travel for scientific visitors. Funding will also be used for graduate student stipend and travel, and for graduate student travel. In addition, this will also provide funding for maintenance of aging equipment in the branch's computer lab, and map and equipment lab. Most importantly, this will provide funding to establish a Branch Image Analysis System by supporting the purchase of both the software and hardware.

W92-70402 **461-31-00**
Goddard Space Flight Center, Greenbelt, MD.
AIR-SEA INTERACTIONS STUDIES
Norden E. Huang 301-286-8879
(461-37-00)

The objectives of this RTOP are to: (1) study the air-sea interaction processes that will support the development of improved coupled ocean-atmosphere models; and (2) develop the necessary remote sensing techniques in supporting the above goal, including instrumentation development, data collection and interpretation, and environment modeling. The plan will have three major components which represent the three correlated but different approaches to the air-sea interaction studies. There is first the field study, which includes Surface Wave Dynamics Experiment (SWADE), High Resolution Remote Sensing Experiment, and possibly the Tropical Ocean Global Atmosphere Coupled Ocean Atmosphere Response Experiment (TOGA-COARE). In these experiments, we are trying to observe the air-sea interaction phenomena under uncontrolled natural environmental conditions. Secondly, we will conduct controlled laboratory experiments to identify and isolate a few dominant mechanisms to study their interactions and quantify their possible influence in the natural environment. And finally, we will try to synthesize our knowledge into theories and models so that the results can be tested against the field observation as well as form the basis for further testing.

W92-70403 **461-31-09**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
SCATTEROMETER RESEARCH
F. K. Li 818-354-2849

The objective of this task is to improve our understanding of the quantitative relationship between radar backscatter from the ocean and basic geophysical parameters such as near surface winds through airborne scatterometry experiments. The primary FY-92 objectives are to analyze the results obtained by the New Airborne Scatterometer (NUSCAT) during the Surface Wave Dynamics Experiment (SWADE) to evaluate the effects of long waves, the backscatter process at low wind speeds and the effects of stress vs neutral winds. A secondary objective is to continue interacting with NASA Headquarters on the planning for the future deployment of NUSCAT, especially in support of ERS-1. We will interact with the SWADE experiment team to obtain the required surface measurements, such as surface wind, wave, and other atmospheric and oceanic parameters for intercomparison with the radar measurements. There are several major items for study. We will utilize data obtained across the Gulf Stream boundaries to evaluate the effects of air-sea temperature difference and to identify the roles of wind stress vs other wind variables. We will investigate the radar backscatter behavior at low wind speed with different wave conditions and will compare the absolute cross section as well as the azimuthal modulations at high and low long wave conditions. Finally, we will intercompare the changes in radar cross section at C- and Ku-bands to evaluate the relative sensitivity to wind changes. We will also perform a preliminary analysis of the cross polarization measurements. We will interact with NASA Headquarters to identify the next experiment opportunity for NUSCAT deployment. An example is the support for ERS-1 verifications. A detailed experiment plan will then be generated in a separate proposal.

W92-70404 **461-31-13**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
SCATTEROMETER STUDIES
P. M. Woiceshyn 818-354-5416

The objectives of this RTOP are to: (1) assess the quality of the ERS-1 and Specialized Experimental Applications Satellite (SEASAT) scatterometer backscatter data and wind-vector retrieval procedures including the physical basis for these; (2) evaluate the NASA Scatterometer (NSCAT) wind retrieval procedures and algorithms during ERS-1 calibration/evaluation (cal/val) utilizing the ERS-1 scatterometer (model) transfer function; (3) evaluate the accuracy of automated wind direction ambiguity removal procedures; and (4) evaluate the importance of physical processes such as sea surface temperature (SST) and wave age in the wind retrieval physics. This includes comparisons between measurements taken from the open sea and those from inland seas such as the Mediterranean. During part of the ERS-1 mission, (including the cal/val period), we will be on site at the European Center for Medium Weather Forecasts (ECMWF) connecting directly to European Space Agency's (ESA's) and ECMWF's databases with our own workstations. Basically, there will be four co-located types of data to be accessed: (1) ERS-1 scatterometer

data; (2) buoy and ship reports; (3) windfield and other analyses, (e.g., SST); and (4) special cal/val data off the coast of Norway. The evaluation will include kinematic fields such as divergence and vorticity. We will convert the ECMWF analysis fields to backscatter to compare to scatterometer backscatter (NRCS) values. This procedure has proved fruitful with SEASAT scatterometer in identifying speed and direction transfer (model) function anomalies, otherwise, not detected using traditional techniques. To assess the influences of physical parameters such as sea surface temperature and wave age, we will develop and test scatterometer functions utilizing non-dimensional analysis techniques that incorporate these parameters. Some progress has already been made in this area. With our co-investigator, Dr. Stefano Zechetto at CNR-Venice, (on an approved ERS-1 research task), we will analyze a long data record that will be taken from his tower-mounted C-Band scatterometer in the Adriatic Sea. Other sea and meteorological measurements will also be simultaneously recorded. We will then test various parameters that could prove to be important in the physics and consequently the retrievals of wind-vectors and wind stress from scatterometer in this environment. We will collaborate with co-investigators, Morton G. Wurtele (UCLA), Anthony Hollingsworth (ECMWF), Evert Attema (ESA-ESTEC), Pascal Lecomte (ESA-ESRIN) and Stefano Zecchetto (CNR-Venice) in the scientific investigations and the establishment of the data-bases noted above.

W92-70405 **461-33-02**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
ALTIMETER MEASUREMENTS OF WIND SPEED AND SEA LEVEL HEIGHT WITH APPLICATIONS TO AIR-SEA INTERACTION STUDIES: PHYSICAL PRINCIPLES AND ADVANCED TECHNIQUES
R. E. Glazman 818-354-7151

Recent analyses of errors in wind speed measurements by satellite scatterometer, radiometer, and altimeter demonstrated that errors in virtually all microwave instruments exhibit geographic and seasonal trends. Also, an error trend (known as the sea state bias) in (GEOSAT) altimeter measurements of sea level height was investigated (Fu and Glazman, 1991). An idealized theory was developed to relate the sea state bias to factors of air-sea interactions (Glazman and Srokosz, 1991). Since all such error biases in satellite measurements are caused by environmental factors, we must improve our understanding of small-scale air-sea interactions manifested in the radar backscatter. In the past year, we have considerably revised traditional views on air-sea exchanges of energy and momentum. This revision has important implications for the interpretation of satellite measurements. The general objective for FY-92 is to complete the development of a new technique for altimeter measurements and to further advance our knowledge of wind-wave dynamics and air-sea exchanges of energy and momentum. Our approach combines theoretical analysis of nadir backscatter and of air-sea interactions with analysis of GEOSAT altimeter data and of in situ buoy measurements. In FY-92, the attention will be focused on the interpretation of altimeter waveforms, on the analysis of momentum transfer from wind to waves, and on the role of the friction velocity in remote sensing signatures. The recent progress in understanding dynamics and statistics of developed seas will be employed to complete the development of physically based models relating altimeter and other remote sensing signatures to the basic, fundamental factors of air-sea interactions. Finally, in collaboration with Prof. V. Zakharov of the USSR Academy of Sciences, we will prepare a state-of-the-art review on wave dynamics theory and its applications in ocean remote sensing.

W92-70406 **461-34-01**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
ADVANCED TECHNIQUES IN OCEAN ALTIMETRY
E. Rodriguez 818-354-5668

During the past four years, we have developed advanced altimeter retracking algorithms and studied the correction of height errors induced by the nonlinear nature of the ocean surface. The objective of the continuing work is to apply these results in order to improve the Topographic Ocean Experiment (TOPEX)/Poseidon data set and make this data set available to the oceanographic community. The improved data set will consist of high accuracy altimeter heights obtained by retracking the altimeter waveforms, an improved electromagnetic bias, and altimeter mispointing corrections. The ultimate objective is to use the improved data set to investigate the characteristics of the global large-scale sea level variabilities. In order to perform the altimeter waveform retracking, we will adapt the sub-optimal maximum likelihood algorithm developed for the processing of (GEOSAT) data to handle the characteristics of the two-frequency, differently sampled TOPEX waveforms, and implement the algorithm in an operational system able to handle TOPEX data in real time. Prior to launch, the algorithm will be tested for accuracy and speed performance using Monte Carlo experiments. After launch, we will use the verification period to assess the accuracy of the retracked data, and to provide independent confirmation of the TOPEX performance. During the TOPEX mission, we will then use the high accuracy TOPEX data set to validate and improve the TOPEX electromagnetic bias height correction algorithm by using repeat track data and data over National Data Buoy Center (NDBC) buoys. Finally, we will generate a smoothed, interpolated, data set sampled at 10 day intervals to extract and estimate the seasonal cycle, and study the dynamics governing the variabilities of the residual signal by regression analysis and Kalman filtering.

W92-70407 **461-37-07**
Wallops Flight Facility, Wallops Island, VA.
SURFACE CONTOUR RADAR (SCR)
E. J. Walsh 303-497-6357

The objectives of this RTOP are to: (1) use the perfectly registered maps of elevation topography and radar backscattered power derived from the Surface Contour Radar (SCR) for measuring wave spectra and other surface parameters for basic wave processes investigations and to support other remote sensor development; and (2) produce topographic maps of terrain at land-water interfaces and otherwise. The SCR and its replacement, the Scanning Radar Altimeter (SRA) mode of the Multimode Airborne Radar Altimeter (MARA), provide digital maps of the topography and backscattered power of the surface beneath the aircraft. These data can be used by themselves to determine the directional wave spectrum of the ocean or, in combination with Global Positioning System (GPS) aircraft positioning, can determine the topography of land regions and the relief at land-water interfaces for coastal studies. In combination with other instruments, these data can make important contributions in the study of air-sea and land-sea interaction. With the improved design of the SRA, this measurement technique has become transportable to other aircraft instead of being resident only on the GSFC P-3 aircraft. This opens up world-wide measurement possibilities by shipping the instrument and using locally supplied aircraft in experiments which would have been cost prohibitive on the present aircraft.

W92-70408 **461-38-00**
Goddard Space Flight Center, Greenbelt, MD.
AIRBORNE ESTAR
David M. LeVine 301-286-8059
(462-26-01)

Salinity is a parameter of the oceans important for understanding ocean circulation and coupling to the global atmospheric and hydrologic cycles. Salinity can be measured with microwave radiometers using two channels (L- and S-band) to remove the effects of water temperature. However, measurements from space at these frequencies require large antennas to achieve adequate spatial resolution. The purpose of this research is to determine whether aperture synthesis can be used to achieve the required resolution with an antenna which it is feasible to deploy from space.

W92-70409 **461-38-02**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
MONITORING GLOBAL SEA LEVEL WITH ALTIMETER TRANSPONDERS
E. J. Christensen 818-354-4199

Spaceborne altimeters measure sea level with a precision of a few centimeters and topographic features on land with a precision of only a few meters. Used in conjunction with altimeter transponders, the vertical height of fiducial sites on land can be measured with accuracies comparable to those obtained at sea. Therefore, altimeter transponders provide the unique opportunity to obtain internally consistent sets of high precision vertical height measurements taken on land and at sea. That is, selected fiducial sites on land can be tied to global sea level data sets produced by missions such as TOPEX/POSEIDON, ESA Remote Sensing Satellite-1 (ERS-1), and future altimeter missions. Altimeter measurements are generally gathered along a repeated groundtrack where the duration of the repeat cycle is typically 10, 17, or 35 days, depending on the mission and mission phase. It is proposed that the transponders be tied to the fundamental reference frame defined by the quasars using Very Long Baseline Interferometry (VLBI), and to the Earth's center using the Global Positioning System (GPS) and satellite laser ranging. It is proposed that dual frequency L1/L2 GPS receivers collocated with altimeter transponders be deployed along the TOPEX/POSEIDON groundtrack. Through differential GPS geodetic positioning, these sites will serve as control points for the network. The altimeter data, combined with the radial position of the orbit, will provide a spatially continuous record of sea level relative to the land based fiducial sites at five- or ten-day intervals. The orbit will be determined using GPS, laser, and perhaps Doppler Orbitography and Radiopositioning Integrated by Satellite (DORIS) tracking data. The tracking and transponder systems enable the tie of global sea level to the fundamental reference frame and to the Earth's center. Transponders can also be used to detect and measure episodical changes in the vertical due to earthquakes and volcanic eruption.

W92-70410 **461-50-00**
Marshall Space Flight Center, Huntsville, AL.
HYDROLOGIC PROCESS STUDIES
R. J. Koczor 205-544-3078

The objectives are to perform a series of studies to assess current remote sensing capabilities to study earth processes and to study hydrologic processes using aircraft and ground-based instruments in various field programs. The talents of university and private contractor groups will be used to develop and measure hydrologic process through various field activities.

W92-70411 **461-51-16**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
AIRBORNE PRECIPITATION RADAR
F. K. Li 818-354-2849

The objective of this task is to develop an airborne rain mapping radar (ARMAR) to demonstrate accurate remote precipitation measurements. ARMAR will be used to verify the technique, technology, and data processing algorithms for future satellite rain measurement missions, such as the planned Tropical Rainfall Measuring Mission (TRMM). It will also be used in the validation of the performance of such spaceborne rain radars. In FY-92, our primary objective is to conduct the first instrument checkout flight on the NASA Ames DC-8. The purpose of this checkout flight is to verify the mechanical and electrical interfaces between ARMAR and the DC-8, demonstrate that the system can obtain radar echoes from terrain and that the radar echo data are properly recorded, and perform preliminary evaluation of the system calibration accuracy. The other objectives in FY-92 are to complete the development of the 24 GHz channel, generate and verify the ground processing system, and fabricate spare units of selected modules to increase the system reliability. We will also participate in the planning activities for Tropical Ocean Global Atmosphere/Coupled Ocean-Atmosphere Response Experiment (TOGA/COARE) and develop a specific experiment plan for the ARMAR deployment. In FY-91, the 14 GHz channel of ARMAR will be fully fabricated. We will install the system on the Ames DC-8 in October of 1991 and complete the mechanical interface checkouts. We will also test the electrical and aircraft data system interfaces. The radar system will then be operated in two checkout flights. The flights will be conducted over ocean and land areas near Moffett field. The echoes recorded will then be processed by a preliminary version of the ground processing system. We will examine the pulse compression sidelobes achieved and will also utilize the ocean radar cross sections and the mean wind measurements of the NOAA Data Buoy Center (NDBC) buoys to evaluate the system calibration accuracy. We will also capitalize on any rain-storm-of-opportunity to demonstrate the system signal-to-noise ratio in actual rainfall. After the checkout flights, we will complete the system operation software and the development of the 24 GHz hardware. We will also procure components and build spare units of selected modules to increase the system reliability. Finally, we will complete the ground processing system checkout in preparation for TOGA/COARE. We plan to conduct a second set of system engineering flights in June/July, 1992 to gain additional operation experience before TOGA/COARE.

W92-70412 **461-51-91**
John F. Kennedy Space Center, Cocoa Beach, FL.
MET DATA PROCESSING SUPPORT
J. R. Nicholson 407-867-2780

The objective is to archive data of a unique nature gathered at Kennedy Space Center (KSC) from mesoscale instrument networks, such as the electric field mill system, winds mesonetwork system, lightning time-of-arrival system, and similar systems. The KSC Data Management computers, Data Processor VAX 6510 and Graphics VAX 6420 are being used to process and archive the data, which then can be made interactively available to users through NASA Science Internet. General planning is complete, and detailed planning concerning certain data sets is underway. Electric field mill data associated with lightning events from the 1970's, including those from the Thunderstorm Research International Program, have been archived on optical disk. The approach will be to: complete the detailed planning and installation of data communications systems; support the Convective and Precipitation/Electrification Experiment and the Tropical Rain Measuring Mission; continue archiving retrospective electric field mill data; systematically archive KSC data sets during the summer of 1991; and plan and begin archiving Geostationary Operational Environmental Satellite (GOES) radiometric temperature and moisture profile data for the east central Florida region.

W92-70413 **461-57-00**
Goddard Space Flight Center, Greenbelt, MD.
TROPICAL RAINFALL MEASURING MISSION (TRMM) PROJECT SCIENCE
Otto W. Thiele 301-286-9006

The objective of this RTOP is to conduct a broad based scientific research program in connection with the Tropical Rainfall Measuring Mission (TRMM). The overall TRMM Project Science Team includes 35 members. However, only the 25 scientists funded by NASA under this RTOP are included here. The scientific effort involves space-based precipitation radar, multifrequency microwave and visible/infrared radiometer studies, combined algorithm developments from multiple sensors, modeling on all time and space scales, techniques for merging gap-filling data from other satellites and in-situ measurements, and assimilation/validation techniques using surface-based rainfall measurements. The TRMM Project Science Team (PST) participation funded under this RTOP is the result of a Headquarter's NASA Research Announcement (NRA) competition. The scientists origins include universities, industry, other agencies, internal NASA scientists, and foreign countries. While the PST is supported in an overall sense by this RTOP, all foreign principal investigators are funded from sources within their own countries. Theoretical investigations and experimental studies using research aircraft and satellite data sources will be used to develop and refine prelaunch algorithms

for the TRMM instruments both individually and collectively. These algorithm developments will form the basis for defining this aspect of the TRMM science data processing system. Modeling studies involving precipitation, either as initialization data or prediction validation, will range from small scale cloud models to global climate and circulation model. Many of the investigations will result from participation in or use of key field experiment data, e.g., the east central Florida Convection and Precipitation Electrification Experiment (CaPE) 1991 and the Tropical Ocean Global Atmosphere/Coupled Ocean Atmosphere Response Experiment (TOGA/COARE) experiment in the tropical west Pacific, 1992/1993. Improving rain measurement techniques with rain gauges, radar, and remote sensing schemes and related sampling/statistical studies and data assimilation investigations with these data will be pursued both in support of algorithm development and intercomparison/validation studies.

W92-70414 **461-57-00**
Goddard Space Flight Center, Greenbelt, MD.
TRMM GROUND TRUTH STUDIES AND PRECIPITATION RESEARCH
Otto W. Thiele 301-286-9006
(461-57-01)

The objective of this RTOP is to develop and manage a validation program for Tropical Rainfall Measuring Mission (TRMM) which includes a number of ground truth sites and a supporting precipitation research component. The following activities are included: (1) precipitation measurement research; (2) background rainfall climatologies of various tropical rain regimes from available data; (3) sampling and statistical studies; (4) rainfall data sets from existing TRMM validation sites; (5) studies of tropical rainfall characteristics and processes; (6) remote sensing techniques and related algorithm development; (7) techniques for validating space-based precipitation measurements; and (8) field experiments. The approaches to be used for this RTOP are listed: continue collecting, processing, and analyzing radar and rain gauge data from established TRMM validation sites, i.e., Cape Canaveral/KSC, Florida, Kwajalein Atoll, Marshall Islands, Darwin, Australia, and Phuket, Thailand; plan extension to add additional sites in crucial climatic regimes, e.g., rain forests; amplify supporting rain studies at Wallops Flight Facility involving radar, rain gauges; calibration, microwave attenuation link studies, aircraft rain radar and radiometer/Ultra High Frequency (UHF) profiler studies; produce climatological rain atlases for TRMM validation sites and elsewhere in the tropics when sufficient data are available; develop radar and radiometer algorithms from surface systems aircraft and satellites for application to TRMM algorithm development; and continue research to understand precipitation characteristics and processes including relation to seasonal and regional differences in the tropics.

W92-70415 **461-61-03**
Wallops Flight Facility, Wallops Island, VA.
GPS/LASER INTEGRATION
W. B. Krabill 804-824-1417

The goal of this program is to develop and refine the combination of airborne Global Positioning System (GPS) positioning and laser ranging technology to an accuracy better than 10 cm, and to apply this technology to acquire surveys of the elevation (topographic height) of polar glacier surfaces at the sub-decimeter level. Repeated surveys in ensuing years would yield a determination of net gain or loss of ice volume over a wide area. Knowledge of the ice budget in polar glaciers will provide an indirect measure of sea level changes and a clear indication of trends in world climate. The availability of this information is critical to inferring the future effects of increased CO2 and methane on the global temperature field. This program combines established airborne laser ranging technology, both profiling and scanning, with a precise application of the DoD's Global Positioning System (GPS). The primary airborne laser system used in this program is the Airborne Oceanographic Lidar (AOL) based at NASA Wallops Flight Facility. The precise ranging capability of the AOL to meet the required tolerances necessary for the glacier surveying application has been previously demonstrated. The technical developments necessary for the success of this research lies in refining the GPS carrier phase tracking technology and in the navigation of the aircraft using a GPS receiver.

W92-70416 **461-62-00**
Goddard Space Flight Center, Greenbelt, MD.
MULTISENSOR AND PROCESS STUDIES
Robert A. Bindschadler 301-286-7611
(578-35-02)

The scope of this RTOP is Multisensor and Process Studies of Polar Oceans. The latter is a new proposal (461-62-09) aimed to improve utilization of passive and active microwaves sensors in the study of process in the polar regions. The focus will be to accurately quantify new ice and open water areas and to estimate associated heat and salinity fluxes with the passive microwave data as the primary data set.

W92-70417 **461-62-00**
Goddard Space Flight Center, Greenbelt, MD.
MULTISENSOR AND PROCESSES STUDIES OF THE POLAR OCEANS
Joey C. Comiso 301-286-9135

The proposed work aims to study the polar regions from space with the following as specific objectives: (1) to accurately characterize the global sea ice cover using multichannel and multisensor techniques; (2) to quantify areal contributions from the different ice types and surfaces especially on lead and polynya regions and estimate heat fluxes from these surfaces; (3) to study the distribution pattern of the seasonal sea ice region and evaluate the influence of growth, decay, and advection to physical and biological processes; and (4) to assess the state of the polar sea ice using historical data of areal cover, ice types, and ice temperatures. The approach is to use primarily multispectral passive microwave data to characterize the global sea ice cover. The global ice cover will be divided into its seasonal and perennial ice components, which in turn will be subdivided into regions to optimize the ability to interpret satellite data accurately. Areas which have been the site of previous in-situ and aircraft studies will be the initial regions of investigation. This study will be complemented by extensive analysis of infrared, visible, and Synthetic Aperture Radar (SAR) data. Current ambiguities in the interpretation of the passive (as well as active) microwave data will be studied. Cluster analysis techniques will be used in conjunction with in-situ observations and radiative transfer model results to identify the signatures of the different surfaces and formulate the physical basis for the classification algorithm in each region. Sensitivity studies to evaluate errors associated with spatial variability in emissivity and backscatter as well as effects due to scaling, antenna pattern, and sidelobe will be made utilizing in-situ, aircraft, spacecraft, and submarine data.

W92-70418 **461-62-10**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
MICROWAVE PROCESS STUDIES OF SEA ICE PROPERTIES
M. R. Drinkwater 818-354-8189
(665-35-10)

The principal goal of this research is to establish, through process studies, relationships between instrument-measured quantities in the microwave frequency range and specific parameters of geophysically significant ice forms. Aircraft, satellite, and in-situ data will be combined, and used in conjunction with empirical and theoretical models to characterize and quantify the scattering and emission response to variations in ice properties. This study focuses on three key ice types controlling surface fluxes of heat, salt, and freshwater; namely, thin or young ice, snow-covered first-year sea ice, and old ice. The objectives for this year are: (1) to select optimal frequency and polarimetric discriminators for ice properties in combined multichannel active and passive microwave data; (2) to define optimal polarimetric parameters for description of the identified geophysically important ice types in the March '88 polarimetry data; (3) to continue with model simulation comparisons with Labrador Ice Margin Experiment

(LIMEX) '89 radar data to evaluate signatures characteristics of new and young, or snow-covered first-year ice forms in calibrated C-band radar images; (4) to conduct a DC-8 flight campaign in the Weddell Sea at the same time as ESA Remote Sensing Satellite-1 (ERS-1), J-ERS-1, and shipborne sea-ice measurements (during the AnZone experiment) in support of surface flux and modelling studies; and (5) to participate in the Polarstern Winter Weddell Sea Experiment in May to July 1992 to make shipborne microwave and surface property measurements. The approach is as follows: to extend the work completed to date by (1) the analysis of the Stokes matrix to determine independent sources of information on snow and ice properties; (2) decomposition of distributed ice targets into distinct scattering components caused by unique mechanisms; (3) evaluate optimal polarization state or polarimetric parameters for ice property extraction by polarization synthesis; and (4) to extend the active-passive analysis of collocated March '88 Arctic microwave data by principal component or eigenvector analysis of this multiple channel (Synthetic Aperture Radar (SAR), Airborne Multichannel Microwave Radiometer (AMMR), K-band Radiometer Mapping System (KRMS)) dataset.

W92-70419 **461-64-00**
Goddard Space Flight Center, Greenbelt, MD.
WAVES IN THE MARGINAL ICE ZONE STUDY USING SAR
Antony Liu 301-286-8534

The study concentrates on wave-ice interaction in the marginal ice zone (MIZ) and the objectives are to study the effects of wave-related processes on the seasonal variations of the ice edge advance/retreat and to establish a better ice-edge prediction model. The approach is to develop wave-ice interaction model and to compare with buoy and remote sensing data. The numerical techniques of extracting wave data from Synthetic Aperture Radar (SAR) imagery by spectral analysis have been developed and utilized for the Labrador Ice Margin Experiment (LIMEX '87 and '89). A coupled ocean-ice interaction code has been developed to include the wave effects and wind stress for the predictions in the MIZ.

W92-70420 **461-64-11**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
SEA ICE POLARIMETRIC DATA ANALYSIS
R. Kwok 818-354-5614

During March 1988, multi-frequency polarimetric radar data were collected in the Beaufort, Chukchi, and Bering Seas with the JPL airborne Synthetic Aperture Radar (SAR). These datasets can be used to obtain a better understanding of the scattering mechanisms of sea ice returns and to obtain extraction of features for discrimination of sea ice in polarimetric data as well as guide the design of classification algorithms for data from single frequency, single polarization radars. Preliminary investigations utilizing C-, L-, and P-band polarimetric data have concentrated on ice type discrimination and characterization in the digital images. Results suggest that polarimetric data can significantly enhance our ability to distinguish between open water, new ice, and thicker smooth ice. The long term goal is to identify the ice types that can be unambiguously labeled in the multi-frequency, polarimetric SAR data utilizing available datasets and ground truths. The approach of the proposed work is to characterize the multi-frequency polarimetric signatures of sea ice in the aircraft data acquired during the 1988 campaign. The focus is on investigating the improvement of the discrimination capability of sea ice in the polarimetric data, the compilation of signatures of thin ice types in polarimetric SAR data, and characterization of the limitations of polarimetry using spaceborne sensors.

W92-70421 **461-66-16**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
OCEANIC REMOTE SENSING LIBRARY
D. Halpern 818-354-5327

The Oceanic Remote Sensing Library (ORSL) serves the research needs of JPL earth scientists involved in studies of ocean circulation, ocean-atmosphere interactions, biogeochemical cycles, atmospheric sciences, remote sensing technology, and climate and global change. With the high cost of periodical literature and with the large numbers of periodicals and technical reports, no individual investigator at JPL has adequate budget resources nor sufficient office space to acquire the necessary literature to conduct state-of-the-art research. ORSL maintains a collection of technical periodicals, reports, and books related to biological, chemical, and physical oceanography, atmospheric sciences, and relevant satellite missions. ORSL provides an efficient and effective circulation procedure. ORSL supports research activities of the oceanographers, including retrieval of scientific literature. ORSL provides an intellectually inspiring area with appropriate audio-visual equipment for meetings and conferences for small groups. ORSL maintains special collections of internal documents, which are available free-of-charge from universities, NASA Centers, ESA, WCRP, NOAA, and many other organizations.

W92-70422 **461-97-01**
Marshall Space Flight Center, Huntsville, AL.
HYDROLOGIC PROCESS DEFINITION AND COORDINATION
R. J. Koczor 205-544-3078

The objective is to investigate process studies related to modelling of surface boundary conditions in climate models and regional mesoscale models. The approach is to establish studies and field programs to model and understand the interactions of water with complex terrain.

Ecosystem Processes

W92-70423 **462-21-00**
Ames Research Center, Moffett Field, CA.
FOREST/CLIMATE INTERACTIONS
D. L. Peterson 415-604-5899

The objectives are to determine the sensitivity of the overall climate system to land-surface mediated energy and water fluxes in the temperate coniferous forest zone. The approach is to interface Forest-BGC, an existing physiologically based model simulating evapotranspiration (ET) and net primary production (NPP) at the watershed level, with the NCAR Community Climate Model (CMM), a global circulation model (GCM). This will be the first instance of using a process-oriented ecosystem model to parameterize the land-surface portion of a GCM, which have historically neglected the land surface vegetation or used empirical parameterizations of it. This will test the extrapolation limits of ecosystem process models in determining the dynamics of ET and NPP at regional scales (1 deg. x 1 deg.). Variables relating to key processes controlling energy, carbon, and water exchange will be derived from remote sensing, digital terrain, in-place measurement and soils data. The variables to be interrelated in a geographic information system, are: (1) site physical properties (slope, aspect, elevation, soil) obtained by automated partitioning of the terrain into hydrologically meaningful landscape units; (2) surface meteorological conditions including radiation balances, canopy/air temperature, humidity, precipitation; and (3) vegetation characteristics, leaf area index, total biomass, and albedo.

W92-70424 **462-22-00**
Goddard Space Flight Center, Greenbelt, MD.
PARAMETERIZATION OF MESOSCALE HYDROLOGY OF SEMIVEGETATED LANDSCAPES USING SATELLITE MULTISPECTRAL IMAGERY: PARTS 1 AND 2
Michael F. Jasinski 301-286-7099

The objectives are as follows: (1) to derive and to test subpixel (or subgrid) parameterizations of common 2-D fractional vegetation cover distributions occurring in natural semivegetated landscapes; (2) to parameterize and to compare the influence of different fractional cover distributions on large scale latent heat, sensible heat, net radiation, and evapotranspiration fluxes; and (3) to further

develop an inverse algorithm that estimates subpixel fractional vegetation cover on a pixel-by-pixel basis using multispectral imagery without ground-truth. Part 1 - Using a stochastic-geometric modeling approach, physically based parameterizations of subpixel vegetation cover and other subpixel cover types (i.e., illuminated and shadowed background) will be derived for common plant spatial distributions that occur in natural and agricultural landscapes. The analytical models will be tested using computer simulations and field experiments using aerial and satellite multispectral data. Once developed, the parameterizations will be used to extend an inverse technique that estimates fractional canopy cover on a pixel-by-pixel basis and that was developed by the author only for Poisson distributed plants. Part 2 - The subpixel parameterizations developed above also will be incorporated into an existing landsurface hydrology model. Energy and moisture fluxes will be estimated by partitioning the flux terms by the relative fractional canopy, shadowed, and illuminated background areas determined by the 2-D distribution. The parameterization will be tested on natural and agricultural regions using LANDSAT, Thematic Mapping (TM), and NOAA Advanced Very High Resolution Radiometer (AVHRR) imagery, and available hydroclimatologic data.

W92-70425 **462-24-00**
Goddard Space Flight Center, Greenbelt, MD.
LAND SURFACE CLIMATOLOGY: AFRICAN SAVANNA
Manfred Owe 301-286-5173

This program will consist of primarily data analysis, e.g., the investigation of relationships between remotely sensed (ground aircraft satellite) observations and surface parameters and processes, and the validation of several models which will be used to study surface and other meteorological parameters and fluxes. This work will lead to a better understanding of remotely sensed measurements and how they relate to the Earth's surface in a semi-arid environment. The high spatial variability of surface physical parameters and climatic variables cause considerable difficulty when attempting to scale point measurements up to large area surface processes. Semi-arid regions of the world are also extremely sensitive to climatic change, and therefore present an excellent opportunity to monitor and study these effects. Data acquired during an eight week field campaign in Botswana during 1989, and an extensive ten year historical data set will be thoroughly analyzed. Work will continue in the area of spatial variability and scaling of surface parameters. Additional work using vegetation index data to improve the microwave observation of surface moisture is also scheduled. Validation of a theoretical approach using NOAA/Advanced Very High Resolution Radiometer (NOAA/AVHRR) data to estimate atmospheric turbidity will be done. Energy balance modelling work using the field campaign data will continue.

W92-70426 **462-25-00**
Goddard Space Flight Center, Greenbelt, MD.
OPTIMAL USE OF ACTIVE/PASSIVE MICROWAVE SENSORS IN RETRIEVING SOIL MOISTURE PROPERTIES OF GRASSLANDS
Peggy ONeill 301-286-8273

This study will examine the use of active and passive microwave remote sensing data to estimate soil moisture profiles of grasslands. The proposed research will focus on the L- and C-band sensors and will seek to: (1) investigate the effect of surface burn treatment (removal of thatch layer) on the microwave emission and polarimetric backscattering coefficients; this involves the analysis of Synthetic Aperture Radar (SAR) (JPL) and Pushbroom Microwave Radiometer (PBMR) data sets obtained during the First ISLSCP Field Experiment (FIFE) over the Konza Prairie grassland (1987 to 1989) and the MAC-HYDRO experiment (including Electronically Scanned Thinned Array Radiometer (ESTAR)) over Mahantango watershed in Pennsylvania (1990); (2) conduct controlled measurements using truck mounted radar and radiometers at the Beltsville test sites to verify and calibrate emission and backscattering models for grass canopies; (3) determine optimum conditions to combine active and passive measurements for large scale soil moisture estimation. A physically based model has been developed to calculate polarimetric backscattering coefficients and brightness temperatures for grass canopies. A field experiment is scheduled for August 1990 and 1991 at Beltsville sites using truck mounted radar and radiometers. The measurements will include bare soil, a grass field planted the current year (no thatch), and a thatched grass field that has been developed over the past two years. Analysis of FIFE and MAC-HYDRO aircraft data sets continues in conjunction with the model predictions.

W92-70427 **462-26-00**
Goddard Space Flight Center, Greenbelt, MD.
SYNTHETIC APERTURE L-BAND RADIOMETER
David M. LeVine 301-286-8059
(461-38-01)

Soil moisture is a highly variable element of the hydrologic cycle which is important in understanding the global hydrologic cycle and its coupling to the environment as well as being important in agricultural management. Surface moisture can be monitored from space using radiometers operating at the low end of the microwave spectrum (e.g., L-band) because of the strong dependence of the dielectric constant of soil on its moisture content. However, the long wavelengths mean that large antennas are needed in orbit to obtain global maps of soil moisture. This research is to develop a technique to create the large antenna apertures required, synthetically using pairs of small antennas and signal processing. The technique is called aperture synthesis and involves making measurements with pairs of antennas at many different antenna spacings. The approach is to build an aircraft prototype of an instrument which could be implemented in space. The proposed instrument is a hybrid which operates at L-band (1.4 GHz) and obtains resolution along-track using real antennas (stick antennas) and uses aperture synthesis to obtain resolution cross-track.

W92-70428 **462-31-60**
Goddard Space Flight Center, Greenbelt, MD.
FIRST ISLSCP FIELD EXPERIMENT (FIFE)
Forrest G. Hall 301-286-2974
(677-22-27; 677-92-22; 677-21-36)

The objective of this RTOP is to better understand (1) the interaction between vegetated land surfaces and the atmosphere -- specifically how the surface vegetation, topography, and soils control the magnitudes of the components of the surface energy budget; (2) how the relationships which express these controls scale from a point to an area level; and (3) the use of satellite remote sensing to monitor the components of the surface energy budget. The approach will be to acquire simultaneous satellite (Advanced Very High Resolution Radiometer (AVHRR), SPOT, LANDSAT, etc.), aircraft (spectral, material, and energy flux through the atmospheric boundary layer) and surface observations of radiometric, atmospheric, meteorological, hydrological, and biophysical parameters of vegetation and soil at sufficient temporal and spatial resolution and over a large enough area to permit proper comparison of satellite derived quantities with actual surface conditions.

W92-70429 **462-32-00**
Goddard Space Flight Center, Greenbelt, MD.
LAND SURFACE CLIMATOLOGY: KUREX
Donald W. Deering 301-286-9186

The objective is to extend scientific understanding of the interactions between land surface climatology parameters and remote sensing variables to sites in the Eurasian and African Continents; specifically Russian steppe and African Sahel vegetation. A better understanding will be sought concerning the manner in which surface vegetation, topography and soils control the magnitudes of the components of the surface energy budget and how aircraft and satellite sensors can be used to infer the energy budget parameters. Field and aircraft data acquisition campaigns will be conducted in conjunction with satellite overpasses during the KUREX-91 and HAPEX-II-Sahel experiments in the Kursk, Russia and Niger, Africa, respectively. This activity

is concerned with the coordination of U.S. activities and acquisitions of remote sensor data as components of the international research programs. Some U.S. science investigations are supported through ground and aircraft campaigns in collaboration with foreign investigators. The KUREX-91 campaign involves 10 U.S. scientists in field and helicopter measurements during a 21-day period in July. The HAPEX-II-Sahel will include several acquisitions of field and helicopter data, plus the acquisition of ASAS bidirectional reflectances and PBMR microwave aircraft data during FY-92.

W92-70430 **462-32-61**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
ECHIVAL FIELD EXPERIMENT IN DESERTIFICATION-THREATENED AREA (EFEDA)
D. L. Evans 818-354-2418

The European International Project on Climate and Hydrological Interations between Vegetation, Atmosphere and Land-Surfaces (ECHIVAL) has as its goal a program to provide a structure for Global Change studies and global system modeling. The overall objectives of ECHIVAL are to: develop the area-averaged parameterization of the water and energy transfer between soils, vegetation, and the atmosphere; produce data sets against which models can be tested and which are relevant for the documentation of changes in these processes due to climate variability and/or the impact of man's activity. As a first phase of this program the energy and water transfer processes are to be investigated in a climatologically sensitive region of Spain, which is threatened by the possibility of gradual desertification as changes in the hydrological regime occur. The EFEDA pilot study has the following goals: to develop improved observation strategies to measure area averaged energy and water fluxes and methods to combine these data in geo-information systems; to obtain data sets which describe the spatial as well as the temporal variability of these fluxes at scales from 1 to 10000 sq. km that can be used to attack the scaling problem; to prepare these data sets in cooperation with modellers for tests of the parameterization in SVAT (Soil-Vegetation-Atmosphere-Transfer) and climate models of the exchange of water and energy between land surfaces and the atmosphere; and to validate observations made from space, which are capable of measuring globally the parameters that describe changes that occur at the land surface and are relevant to the variability of the energy and water vapor transfer process.

W92-70431 **462-33-00**
Goddard Space Flight Center, Greenbelt, MD.
BOREAL FIELD EXPERIMENT (BOREAS)
Piers J. Sellers 301-286-4173

The objective of this RTOP is to better understand the interaction between vegetated land surfaces and the atmosphere, specifically how the surface vegetation, topography and soils control the magnitudes of the components of the surface energy budget in the Boreal Forest; to understand how climate affects the surface ecology; the use of satellite remote sensing to monitor the ecosystem structure and function and components of the surface energy budget; and establish a distributed information system to support research by the science community. The approach will be to acquire simultaneous satellite (AVHRR, SPOT, LANDSAT, etc.) aircraft (spectral, material radiometric, atmospheric, meteorological, hydrological, and biophysical) parameters of vegetation and soil at sufficient temporal and spatial resolution and over a large enough area to permit proper comparison of satellite derived quantities with actual surface conditions. These data will be documented and archived in a land data system for access by the general scientific community.

W92-70432 **462-41-61**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
SATELLITE RADAR FOR FOREST STRUCTURE
J. B. Way 818-354-8225
(579-41-08)

Multi-temporal measurements of forest ecosystems may be critical in resolving ambiguous interpretations of microwave backscattering from architecturally complicated forest canopies in the presence of spatial and temporal variability in scene characteristics. It is postulated that multitemporal microwave observations can be utilized to separate weather related scene variance from phenologic development. In addition, changing seasonal environmental conditions enhance or subdue certain components of the radar backscatter. The key questions being addressed in this study are: (1) what are the magnitudes of seasonal variation in the microwave backscattering coefficient as a function of wavelength and polarization vectors in response to naturally occurring temporal variability in monospecific forest stands which are characteristic of the temperate deciduous and coniferous forests and boreal forests; (2) how are these variations in the backscatter coefficient quantitatively related to specific forest stand and environmental properties via the relevant scattering mechanisms, and how can this information be connected to quantities of ecological interest; (3) can SAR data be adequately calibrated (in both a relative and an absolute sense) to permit use of the data in conjunction with microwave scattering models, to permit its use in multitemporal comparisons and to permit site to site comparisons of globally distributed forests, and if so, what are the most efficient cost and time techniques and how can they best be implemented with orbital sensors such as ERS-1; and (4) given the observed temporal variations in backscatter and the associated calibration limitations, what ecologically useful information can be inferred from multitemporal SAR observations via change-detection retrieval? To address the above questions, we are using multi-season ERS-1 multi-seasonal SAR data sets of test sites (Bonanza Creek Experimental Forest in Alaska, Duke Forest and Michigan Biological Station) in the U.S. Ground truth measurements collected simultaneously with the satellite data are being used in conjunction with existing radar models to determine which of the canopy properties are contributing to the backscatter at all wavelengths and polarizations. To date, freeze-thaw conditions have been obtained in Alaska, spring and summer conditions have been obtained over Duke, and winter-spring and summer data sets have been acquired over Michigan with AIRSAR.

W92-70433 **462-41-80**
Goddard Space Flight Center, Greenbelt, MD.
GLOBAL INVENTORY MONITORING AND MODELING EXPERIMENT
Compton J. Tucker 301-286-7122
(199-30-90)

The objective of this RTOP is to develop the techniques and scientific basis for studying terrestrial renewable resources at regional, continental, and global scales with multilevel satellite remote sensing data. Satellite data will be obtained at spatial resolutions of 30 m, 80 m, 1 km, 4 km, and 15 km for selected local areas (30 and 80 m), regional test sites (1 km), continental test areas (4 and 8 km), and the entire planet (15 km). These data will be analyzed to provide high temporal frequency vegetation biomass and condition information for assessing productivity, land cover mapping, deforestation, insect and disease upsurges, and other large-scale vegetation information of interest to global science questions such as the earth's radiation budget, the carbon cycle, and the hydrological cycle.

W92-70434 **462-43-00**
Ames Research Center, Moffett Field, CA.
BIOGEOCHEMICAL CYCLING RESEARCH ON THE OREGON TRANSECT
D. L. Peterson 415-604-5899
(199-30-72)

The objectives of this project are to model the processes of carbon, nitrogen and water cycling through temperate coniferous forests and to develop the principles of how nitrogen and water interact to control carbon assimilation and allocation in intact ecosystems. The approach is to test an existing ecosystem model of carbon, nitrogen and water fluxes and interactions through a combination of field and remote sensing studies during an intensive multisensor aircraft campaign. This test of principles, involving surface climate, nutrient cycling and remote sensing, will be used

to specify minimum general measurements. These techniques will then be expanded to companion sites the following year, and to support a workshop in the third year. Sensor data from a Canadian instrument, the Fluorescence Line Imager, will be added to the data set.

W92-70435 **462-43-70**
Goddard Space Flight Center, Greenbelt, MD.
FOREST ECOSYSTEM DYNAMICS -- PHASE II
Darrel L. Williams 301-286-8860

The overall objective of the Forest Ecosystem Dynamics (FED) project is the development of a single, integrated mathematical model which links individual submodels of forest growth and succession, soil processes, and the radiation regime within and external to the soil/forest complex, in combination with ground-based and satellite observations, in order to understand the dynamics of boreal forest ecosystem evolution over a variety of temporal and spatial scales. The approach is to identify and define linkages between the sub-models (i.e., components within ecosystems) in order to understand how fluxes of matter and energy pass through the soil-plant-atmosphere continuum. We propose to focus our activities on four specific sub-areas of research for Phase II: model integration, data analysis and integration, model validation, and model exercising.

W92-70436 **462-60-00**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
ELECTRONICALLY STEERED THINNED ARRAY RADIOMETER STUDY (ESTAR)
C. S. Ruf 818-354-7257

This task will support Jet Propulsion Laboratory (JPL) work on system calibration error analysis for the Electronically Steered Thinned Array Radiometer (ESTAR). The error budget for the current aircraft instrument calibration will be expanded to include second order effects which should dominate the second generation aircraft and proposed spacecraft calibration. A more refined estimate of science algorithm precision and accuracy will result. This task will also support a design study for the optimum cross-correlator subsystem capable of handling many wideband channels with minimum power requirements. A NASA Science Working Group has been established to examine the utility of ESTAR for soil moisture and ocean salinity retrieval. Drs. E. Njoku and C. Ruf are supporting this working group and have been asked to analyze the system error issues and to investigate the complementarity between ESTAR and Synthetic Aperture Radar (SAR). In addition, an ongoing cooperative effort exists between JPL and GSFC, LaRC, UMass and the USDA examining preliminary system and subsystem designs. A preliminary design will be done for minimum power on the wideband correlator subsystem.

W92-70437 **462-61-00**
Goddard Space Flight Center, Greenbelt, MD.
REMOTE SENSING SCIENCE
Donald W. Deering 301-286-9186

The fundamental studies under this RTOP address a broad range of technical issues bearing on the remote sensing of the Earth's land surface. The objective is to develop the scientific understanding and techniques that will allow accurate extraction of land surface physical and biological properties from Earth satellite data. Basic research is conducted that includes goniometric measurements of the bidirectional reflectances of soil and plant elements in the laboratory and field, as well as field measurements of vegetated surfaces to determine their bidirectional reflectance distributions. Models are developed from radiative transfer theory and validated using experimental data. Simple, physically based analytical models are developed from the experimental data that have direct application to satellite data analysis. Knowledge based expert system concepts are applied to develop and apply robust techniques for the extraction of surface properties from remotely sensed data.

W92-70438 **462-61-00**
Ames Research Center, Moffett Field, CA.
OPTICAL SCATTERING OF PLANT CANOPIES
V. C. Vanderbilt 415-604-4254

The objective of this project is to determine the relationships between the polarized light scattering characteristics of leaves and plant canopies and the biological properties of the leaf/plant such as plant development stage and leaf relative water content. The effect of the atmosphere on polarized light from plant canopies will be investigated. The approach involves studies conducted at three levels - laboratory, field, and aerospace. In the laboratory and field phases of the research, both single leaves and plant canopies will be measured allowing comparison of their spectral polarized light scattering properties and their physiological and morphological characteristics. The aerospace portion of the research will be conducted with the aid of a specially modified polarization scanner which will be flown on the ER-2. Targets of known light scattering characteristics will be measured on the ground and from the ER-2, thereby allowing the effect of the disturbing atmosphere to be better understood and modelled.

W92-70439 **462-61-03**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
HETEROGENEOUS SCENE MODELS
D. J. Diner 818-354-6319

Quantitative studies of the surface from space require the ability to infer accurate spectral reflectances, bidirectional reflectance distributions, and hemispherical albedos from top-of-atmosphere (TOA) radiances. The purpose of this RTOP is to develop practical methods for retrieving these land surface (and required atmospheric) properties, with particular emphasis on computational rapidity while meeting the accuracy requirements of the scientific community. We have the following objectives: (1) development and validation of surface reflectance retrieval algorithms; (2) development and application of atmospheric optical property retrieval algorithms; and (3) assessment of polarization and topographic effects. Determination of the radiance arising from photons diffusely transmitted from the surface to space must be computed using radiative transfer algorithms and our surface retrievals are based on this formalism. Our radiative transfer-based retrieval code includes surface directional properties. Our approach to retrieval of atmospheric aerosol optical properties (opacity, single-scattering albedo, and size distribution parameter) is dependent on the information content of off-nadir imagery, and provides part of the rationale for the EOS MISR experiment. Our radiative transfer codes are able to simulate realistic nadir and multi-angle imagery and we are also investigating the use of ASAS data to assist in validating these retrieval techniques. A long term objective is to have an understanding of the relative importance of polarization and topographic effects and to make adjustments, if necessary, in the retrieval process.

W92-70440 **462-61-08**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
MODELS OF DIRECTIONAL EMISSION FROM ROUGH SURFACES
J. A. Crisp 818-354-9036

The objective of this RTOP is to develop theoretical models for predicting the spectrally-dependent directional emittance, reflectance, and polarization from natural surfaces. The models will be used to study the effects of surface roughness, compositional and thermal gradients, and atmospheric extinction on the radiance that can be detected by remote sensing instruments at thermal infrared wavelengths. The approach is to use a hierarchy of theoretical models to find the directional reflectance and emittance from realistic surfaces. In the simplest method, the surface has been modeled as a flat slab, to serve as a baseline for comparison with other models. The second class of methods includes the effects of surface roughness by modeling the surface as a series of facets. The third class of methods will include both a faceted surface and more than one refractive index interface. The final class of models will treat the surface as a particulate medium. We will test these models by comparing the results with

a broad range of laboratory and field measurements of well-characterized geological surfaces.

W92-70441 **462-62-04**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
RADAR SCATTERING FROM FORESTED AREAS
H. A. Zebker 818-354-8780

The specific objective of this study is to improve our understanding of the interaction of radar signals with forested terrain, with the long term goal of developing algorithms permitting the inversion of remotely sensed radar measurements to solve for geophysical factors describing the various forest canopies around the world. We will address this problem through a set of interrelated tasks: (1) development of a multipolarization, multifrequency radar scattering model applicable to a wide variety of forest types; (2) collection of primary radar data using the DC-8 SAR over those forests; (3) verification of the scattering models using the radar data and in situ ground truth observations; and (4) inversion of the model results for geophysical forest parameters. Our modeling approach is to use a layered discrete scatterer model, in which each scatterer such as a twig or leaf is individually modelled, then combined statistically with other scatterers to form the aggregate radar interaction model corresponding to a layer of scatterers. These layers are then combined as required to completely describe the backscatter process from that modeled forest. The advantages of this approach are that the number of layers may be varied to account for different forest structures, and that the predicted scattering is quite well related to individual densities of the scattering elements (branches, leaves, trunks, and the like). Absolutely calibrated data are required for accurate model fitting. We have found that inclusion of 3 to 5 known reflecting targets in a scene permits the multipolarized data to be calibrated to an accuracy of about 2 to 3 dB, and we will be outfitting all of our study sites with corner reflectors. Some ground truth data will be collected by us; however, we rely on our collaborators within the ecology community for most ground data collection and interpretation. We have ongoing collaborative efforts with the OTTER team (OSU, ARC), and the TREE team (Duke U.) for the rain forest data collected in Belize in 1990.

W92-70442 **462-62-05**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
SOIL MOISTURE MEASUREMENTS
J. J. Van Zyl 818-354-1365

The purpose of this investigation is to study the feasibility of measuring soil moisture with imaging polarimetric synthetic aperture radars. Polarimetric Synthetic Aperture Radar (SAR) data were acquired during two hydrology experiments during FY-90, one in Arizona and one in Pennsylvania. We shall use models of radar scattering to invert the radar data to find surface dielectric constant. The values inferred from the radar data will be compared with the in situ measurements to assess the feasibility of measuring dielectric constants using polarimetric SAR data. Once the dielectric constants are known, we shall use existing soil models to invert the dielectric constant values to infer soil moisture. In addition, we shall participate in two hydrology experiments, one in Spain and one in Italy in 1991. We shall deploy calibration equipment and make point measurements of soil moisture during the experiments. We shall calibrate the data and co-register images from different dates. All calibrated data will be distributed to interested investigators.

W92-70443 **462-63-00**
Goddard Space Flight Center, Greenbelt, MD.
CALIBRATION OF AVHRR VIS/NIR
Brent N. Holben 301-286-2975

The objective is to provide a radiometric calibration of the NOAA AVHRR visible and near-IR systems. Four basic approaches will be applied to understand radiometric spectral sensor response. The first approach uses molecular scattering over the oceans to provide a known radiance to the sensor in the visible band. Sun glint will be used to transfer the calibration to the near-IR band and thus have an absolute calibration. The second approach, desert method, requires spectral and temporal constancy throughout the lifetime of the satellites such that the satellite values can be compared relative to one another. The third method, cloud calibration, relies on the ratio of cloud reflectances in both bands (which can be accurately modeled for high bright clouds) to be compared to satellite data. Therefore, the theoretical reflection ration can be used to derive very accurately the calibration ratio between the two channels. The above approaches apply to afternoon AVHRR passes. We propose a polar ice cap calibration during the summer solstices in which the morning and afternoon satellites image the same areas at nearly constant solar zenith angles 14 times per day. To eliminate view angle and azimuth angle effects, the data set will be restricted to nadir views. They will provide a relative calibration between all satellites.

W92-70444 **462-66-01**
Marshall Space Flight Center, Huntsville, AL.
PROCESS STUDIES: ECOSYSTEM DYNAMICS
R. J. Koczor 205-544-3078

The objectives of this RTOP are to perform fundamental studies aimed at improving our understanding of the impact of the hydrologic data on Earth ecosystem dynamics; to establish a NASA Headquarters remote sensing of biosphere and atmosphere interactions science and management role; and to coordinate NASA and non-governmental research in this area.

W92-70445 **462-72-00**
Goddard Space Flight Center, Greenbelt, MD.
LASER ALTIMETER FOR DIGITAL TOPOGRAPHY
J. L. Bufton 301-286-8591
(463-11-15)

The objectives of this RTOP are to study the instrument technology and techniques of laser sensing of Earth surface topography from a spacecraft platform; and to identify the laser altimeter and spacecraft interface capability that can meet digital topography science requirements and data acquisition objectives that are contained in the NASA Topographic Science Working Group Report. Research and development activities involve the definition of laser altimeter instrument technologies and the use of laser altimeter instrumentation from a spacecraft platform. A Phase A conceptual design study will be conducted of a mapping laser altimeter that is capable of along-track and cross-track measurements from space. Altimetry data sets will be used to produce digital elevation maps of surface topography. The goal for surface topography measurement is sub-meter vertical resolution for a sensor footprint of 30 to 200 meters. The Phase A study will consider laser transmitters based on high-power, pulsed solid-state lasers, optical receivers based on avalanche photodiode detectors, and spacecraft position and attitude sensors based respectively on the Global Positioning System (GPS) and star cameras. Small spacecraft and expendable launch vehicle technologies are critical to this sensor concept.

W92-70446 **462-74-01**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
AIRBORNE INTERFEROMETRIC TOPOGRAPHY
H. A. Zebker 818-354-8780
(465-67-04)

The objective of this study is to develop an instrument capable of mapping the topography of the Earth's surface at high spatial and vertical resolution, using the technique of radar interferometry to produce a data set which is useful in a variety of Earth science investigations. Our specific objectives here are to implement such an instrument on an aircraft system in order to prove the technology in an operational environment, begin to acquire and distribute a data set over a variety of terrain types which will be available to the science community, and develop algorithms and procedures applicable to future spaceborne missions such as TOPSAT. Our approach, consisting of an instrument we call TOPSAR, is to implement a cross track interferometer capability on the existing NASA DC-8 radar for precision topographic mapping. This approach is of minimum cost as it utilizes the existing C-band multichannel radar hardware as much as possible. The major changes required

to the existing system are procurement of two new radar antennas, fairings for mounting them on the DC-8, and changes to the radar rf switching network. Eventually, a new radar processor which produces low phase noise images will be needed. Our goal is to produce approx. 2 m height accuracy DEMs with precisely co-registered L and P band polarimeter radar images. This capability follows from operating the L and P band systems simultaneously with the interferometer, and processing the raw data in an integrated manner. This will result in geometrically rectified and cartographically accurate polarimeter data. The three year approach is to (1) develop a new set of interferometric radar antennas, integrate them with the DC-8, and verify the installation with test flights in the U.S. and Italy; (2) develop a phase-accurate processor with aircraft motion compensation algorithms, and produce a sample 2 m map; and (3) integrate the system with the DC-8 P and L band radars in an operational manner. In addition, we will, during the course of this study, acquire data over a variety of sites of differing Earth science applications to support the science community at large and familiarize them with the generation and use of digital topographic data.

W92-70447 **462-75-00**
Goddard Space Flight Center, Greenbelt, MD.
MULTIDIRECTIONAL SENSOR OPERATIONS
James R. Irons 301-286-8978

The Advanced Solid-State Array Spectroradiometer (ASAS) is an airborne imaging spectroradiometer capable of acquiring digital image data from multiple view directions. The goal of this RTOP is to better support the scientific objectives of terrestrial ecosystem field experiments and EOS sensor system development by improving the ASAS data acquisition and processing systems. The technical objectives are to: (1) expedite data processing and improve data quality control; (2) extend the maximum view zenith angle and provide for aircraft yaw compensation; and (3) improve performance and reliability of the sensor system. The approach is to develop a dedicated data processing system to expedite processing and improve quality assessment; design and fabricate a new aircraft mounting bracket for view angle extension and yaw compensation; and replace the sensor detector array to improve reliability.

W92-70448 **462-79-00**
Ames Research Center, Moffett Field, CA.
BIBLIOGRAPHY FOR LAND PROCESSES PUBLICATIONS
J. G. Lawless 415-604-5900

The objective of this work is to provide a bibliography to Headquarter's Earth Science and Applications Division that will document the peer-reviewed publications produced as a result of NASA's Land Processes Research Program (1984 to date). This bibliography will be used to determine the impact of the program and will be used by managers and scientists to identify articles of interest and trace the history and contributions of land processes research.

W92-70449 **462-79-00**
Ames Research Center, Moffett Field, CA.
AIRBORNE SCIENCE MANAGEMENT OPERATING WORKING GROUP SUPPORT
J. G. Lawless 415-604-5900
(465-69-00)

The objective of this work is to provide general support to NASA's Airborne Science Management Operation Working Group. Support will be provided for planning activities related to Earth Surface Remote Sensing Program usage of NASA's science applications aircraft. Staff support is also necessary for regular meetings of the Aircraft Science Management Operations Working Group.

W92-70450 **462-97-00**
Goddard Space Flight Center, Greenbelt, MD.
HYDROSPHERIC PROCESSES PROGRAM SUPPORT FOR PROCESS STUDIES
Antonio J. Busalacchi 301-286-6171

The objective of this RTOP is to support process studies research activities in the Goddard Laboratory for Hydrospheric Processes.

Biogeochemical Processes

W92-70451 **463-11-09**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
PHYTOPLANKTON DYNAMICS OF NORTH PACIFIC OCEAN
C. O. Davis 818-354-5395

This research focuses on the use of AVHRR Sea-Surface Temperature (SST) and ocean color data from the CZCS and future instruments for the study of primary productivity and phytoplankton dynamics in highly productive ocean systems. Initially, the focus is on using extensive in situ data for optical characterization of major oceanographic regions and for verification and interpretation of the satellite data. Subsequently, the goal is to use the satellite data validated with mooring data coupled with models based on the cruise data to extrapolate those results in time and space to produce regional estimates of phytoplankton biomass and production. Study areas to date include: Coastal upwelling systems along the California coast, the North Atlantic Spring Bloom, and the Equatorial Pacific. Extensive in situ optical data were collected in each of these study areas in collaboration with large field experiments. Those data were processed and algorithms for using optical data to estimate phytoplankton biomass and productivity are being developed. A major goal this year is to develop a data base system for this data and all future in situ optical data which will include the calibrated data and a library of readily applied algorithms for ship shadow correction, quality control checks, K(lambda), L(sub W)(lambda), etc. Beyond this we are using satellite ocean color and SST data in total and new production models and eventually in coupled physical-biological models to obtain regional and basin scale estimates of phytoplankton productivity. This project is considered a component of the Joint Global Ocean Flux Study (JGOFS), an international study of the flux of carbon through the ocean.

W92-70452 **463-11-10**
Wallops Flight Facility, Wallops Island, VA.
AIRBORNE OCEANOGRAPHIC LIDAR (AOL)
F. E. Hoge 804-824-1567

The primary objectives of this RTOP are to continue the scientific and instrument research, development, and applications of the NASA/GSFC Airborne Oceanographic Lidar (AOL) leading to improved understanding of global biogeochemical cycling using both active and passive measurements of phytoplankton chlorophyll, phycoerythrin, and phycocyanin pigment and dissolved organic matter. Our approach is to focus efforts upon: (1) continued cooperative field investigations with widely-recognized oceanographic institutions, government laboratories, and field centers; (2) continued improvement of the airborne pulsed laser measurement of subsurface scattering layers using the AOL; and (3) direct application of active-passive correlation spectroscopy (APCS) to AOL data for advanced ocean color satellite sensor band selection and algorithm development. Specifically: (1) continue interagency cooperative oceanographic field investigations such as the Joint Global Ocean Flux Study (JGOFS) and Office of Naval Research's (ONR) Marine Light Mixed Layer (MLML) investigations and DOE's new Ocean Margins program; (2) improve the temporal/depth-resolved electro-optical components of the AOL to allow the detection and quantitative measurement of particulate volumetric backscatter over a wide range of signal levels; (3) participate in the JGOFS Central Equatorial Pacific experiment and engage in cooperative field missions with Italian oceanographers in the Adriatic Sea; (4) conduct ocean color experiments using the dual active/passive modes of the AOL (such

as, active (lidar) validation of passive ocean color in-water algorithms especially as they may relate to planned EOS/MODIS and SeaWiFS satellite sensors).

W92-70453 **463-43-00**
Ames Research Center, Moffett Field, CA.
REGIONAL CARBON FLUX IN HIGH LATITUDE ECOSYSTEMS
G. P. Livingston 415-604-3232
(148-90-00)

This research addresses the regional-seasonal estimation of carbon flux and the regulatory exchange processes for select northern high-latitude ecosystems. The approach is through integration of in-situ flux observations, simulation modeling, and land surface stratifications based upon satellite and aircraft remote sensing. Initial surface observations will determine the magnitude and variability of methane and carbon dioxide emissions along select environmental gradients to characterize the regulatory biogeochemical processes. Net emissions will be estimated within ecological spatial strata derived from SPOT, TM, AVHRR, SAR and CIR photography. Various estimation approaches of regional flux will be assessed based upon chamber, eddy correlation, and isotopic analyses of gas emissions, sampling and geostatistical theory, and the remote sensing derived strata. Surface flux measurements coupled with multitemporal coregistered AVHRR data will provide the basis for an assessment of the seasonal variability of carbon flux for Arctic tundra ecosystems. Various sources of error in the regional-seasonal estimates will be identified and their contribution to the overall estimated precision evaluated. The significance of high latitude ecosystems in the global carbon budget will be addressed through atmospheric modeling using existing photochemical models developed at ARC.

W92-70454 **463-43-07**
Goddard Inst. for Space Studies, New York, NY.
PALEOECOLOGICAL STUDIES OF CH4 EMISSIONS
Dorothy Peteet 212-678-5587
(148-90-00)

The general objectives are to trace the postglacial development of the present distribution of peat bogs at mid-high latitudes using transects across Alaska, Canada, and the major peatland region of the Soviet Union. The relationship between areal extent of peatlands to biogeochemical cycles on a global scale will be made by comparison of the timing of subarctic peatland formation in these regions with the timing of natural variations in atmospheric methane concentrations from ice core data. High latitudes not only are thought to play a role in driving climate change, but are sensitive reflectors of change at present. The relationship of peatland formation to climate change will be determined by comparing the peatland stratigraphy and chronology with independent glacial history of these regions and palynological and macrofossil data in the sediment cores. Coastal Alaskan basal peatland sections retrieved in 1989 were radiocarbon-dated during the spring of 1990. Summer 1990 field research focus was upon the establishment of timing of modern major Alaskan peatland regions, both coastal and inland. The 1991-92 research will expand this objective to Canada and the USSR.

W92-70455 **463-61-00**
Ames Research Center, Moffett Field, CA.
TROPICAL LAND USE CHANGE AND NITROGEN TRACE GASES
P. A. Matson 415-604-6884
(199-30-62)

The objective of this research is to determine the extent to which tropical agriculture, pasture, and fertilizer use contribute to the global increase of nitrous oxide. Furthermore, this research will determine the fractions of nitrogen flux to the atmosphere in nitrous oxide, nitric oxide and ammonia, as a function of soil fertility and vegetation canopy characteristics. The approach is to measure nitrous oxide fluxes and controlling soil processes in a variety of natural and agricultural systems in Brazil, Africa, southeast Asia, and Hawaii; sites will be selected within a matrix of common management practices. Global models that estimate fluxes based on soil type, temperature and moisture regimes, vegetation activity, and land use will be developed. In addition, research on the fractions and controls of relative nitrous oxide, nitric oxide and ammonia fluxes will be carried out experimentally in well-studied agricultural research sites in Hawaii, and will include soil flux estimates, eddy correlation flux estimates between canopy and atmospheric remote sensing and model development at both soil and canopy levels.

W92-70456 **463-75-61**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
AVIRIS OPERATIONS
R. O. Green 818-354-9136

The objective is to support the activities required to acquire, calibrate and distribute data with the Airborne Visible/Infrared Imaging Spectrometer (AVIRIS) for NASA sponsored science investigators in fiscal year 1992. AVIRIS measures the total upwelling radiance incident at the sensor in 224 channels with nominally 10 nm spectral sampling and 10 nm spectral response functions (FWHM) from 400 to 2450 nm in the electromagnetic spectrum. Data from these channels are acquired at nominally 20 by 20 m spatial resolution with an 11 km by up to 100 km image extent. All distributed AVIRIS data are calibrated with respect to spectral, radiometric and geometric characteristics. A brief summary of the AVIRIS operations assumptions for fiscal year 92 are as follows: (1) routine and preventative maintenance will be undertaken such than no degradation in performance occurs; (2) for 6 contiguous months AVIRIS will be at JPL for preventative maintenance, including recoating damaged spectrometer mirrors and replacing the fiber harness which will have reached expected end-of-life; (3) the data acquisition deployments away from JPL will be supported (Moffett Field, CA; Melborne, Australia plus shipping through Guam and Hawaii; San Antonio, TX; Wallops Island, VA; and Patrick AFB, FL); (4) up to 1000 calibrated AVIRIS scenes will be distributed to sponsored investigators; and (5) cost estimates for transportation of AVIRIS and travel to support launch site operations are based upon FY-91 actual costs and may therefore change. The objectives will be fulfilled through the following activities at JPL: (1) AVIRIS task and RTOP management; (2) calibration and validation science; (3) mission planning and experiment coordination; (4) data decommutation, calibration and distribution; (5) sensor operations, calibration and maintenance; (6) sensor and ground support equipment shipping as well as travel for launch site support personnel; and (7) acquisition of expendable supplies such as high density, archive and distribution tapes.

W92-70457 **463-99-00**
Ames Research Center, Moffett Field, CA.
EARTH OBSERVATIONS COMMERCIAL APPLICATIONS PROGRAM
J. S. Salute 415-604-5596
(142-20-37)

The objective is to create partnerships between NASA, U.S. private sector, U.S. educational and other non-profit organizations and other U.S. government agencies to increase commercial usage of NASA developed remote sensing technology. This includes providing operational users with access to advances in remote sensing techniques and technologies for improved services and operations, while fostering the utilization of remote sensing for national economic benefit. The approaches taken within this RTOP include: (1) using proven techniques and data analysis methodology to address newly defined environmental analysis problems; (2) extrapolating proven techniques developed to address a specific discipline requirement to new disciplines or research areas; and (3) developing new spatial data management and analysis techniques for applying remote sensing and geographic data to practical environmental problems.

Atmospheric Processes

W92-70458 **464-10-00**
Langley Research Center, Hampton, VA.
BIOSPHERIC/ATMOSPHERIC INTERACTIONS
Joel S. Levine 804-864-5692

This RTOP includes the following topics: (1) global biomass burning and biogenic gases (a field measurement program to quantify particulate and gaseous emissions from biomass burning, to quantify pre- and post-burn biogenic gas emissions, and to quantify the global/areal extent of biomass burning from satellite images); (2) wetlands project (the study to establish relationships between CO2 exchange and remote sensing parameters in wetlands vegetation photosynthesis and corresponding canopy reflectance characteristics); and (3) wetlands field research support (to provide laboratory and field equipment support of biospherics wetlands research experiment to study gas emissions and remote sensing relationships in wetland).

W92-70459 **464-10-00**
Langley Research Center, Hampton, VA.
ATMOSPHERIC PROCESSES/STRATOSPHERE
W. Ray Hook 804-864-6055

The objective is to support field measurements, theoretical and analytical studies, and laboratory investigations relevant to stratospheric processes. Field measurements include far-IR balloon measurements of key hydrogen and halogen gases, ozone monitoring with ground-based microwave techniques, and airborne lidar ozone and aerosol measurements. Analytical and theoretical efforts include analysis of high resolution atmospheric spectra to quantify trace gas concentrations and trends, computational chemistry studies focused on molecular radicals and heterogeneous systems, and development of accurate and efficient techniques for incorporating non-equilibrium radiative effects in trace gas retrieval algorithms. Laboratory studies focus on determination of infrared spectroscopic parameters required for atmospheric remote sensing experiments. Field measurement and laboratory tasks are supported at other institutions based upon NASA Headquarters recommendations and presently include mass spectrometry of neutral constituents, free radical measurements, atmospheric spectroscopy, and infrared laboratory spectroscopy.

W92-70460 **464-11-05**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
OZONE MEASUREMENTS
J. J. Margitan 818-354-2170

Vertical profiles of ozone in the stratosphere will be measured by a dual channel UV photometer flown as part of research balloon flights. Ozone profiles will be obtained on ascent and descent with 1 second (better than 100 meters) resolution. These data will serve as a comparison to other in situ and remote sensing techniques. This research effort is a collaborative project with the NOAA Aeronomy Laboratory. The ozone data will be useful in improving our understanding of stratospheric chemistry, and in particular in assessing the degree of discrepancy between measurements and calculations of ozone near 40 km. Ozone measurements will also be made aboard NASA's high altitude research aircraft. This research will be a part of the UARS Correlative Measurements Program.

W92-70461 **464-11-07**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
LASER DIODE SENSOR
C. R. Webster 818-354-7478

The Balloon-Borne Laser In-Situ Sensor (BLISS) and Aircraft Laser Infrared Absorption Spectrometer (ALIAS) tasks have as their primary objective the collection of reliable data on the concentrations, distributions, and variabilities of the minor and trace species in the stratosphere. These data are to be used by modelers and dynamicists to assess and predict the effects of change in the chemical content of the upper atmosphere due to anthropogenic activity. The BLISS instrument uses tunable diode lasers (TDLs) to measure the absorption due to selected species between the balloon gondola and a lowered retroreflector which defines up to a 1-km absorption path. The TDL beam in use is stabilized onto the lowered retroreflector by use of an optical tracking system. Several species can be measured simultaneously to the 0.1 ppbv level in sensitivity, throughout a diurnal cycle, and with the additional possibility of altitude profiling. The current measurement capability includes NO, NO2, O3, HNO3, HCl, H2O, CH4, N2O, CO2, and minor gas isotopes. A compact version of this instrument was designed and built, and has recently undertaken successful test flights on the ER-2 aircraft. This Aircraft Laser Infrared Absorption Spectrometer (ALIAS) instrument employs a multipass gas cell with measurement capability for NO2, N2O, HCl, CH4, H2O, and HNO3. ALIAS will participate in the upcoming AASE-2 Arctic campaign out of Alaska and Maine.

W92-70462 **464-12-00**
Ames Research Center, Moffett Field, CA.
AIRBORNE IR SPECTROMETRY
S. Wegener 415-604-6278

The objective is to obtain information on the spatial and temporal distribution of stratospheric constituents for use in testing current theories of stratospheric chemistry, especially ozone depletion. The approach is to deploy Infrared (IR) absorption and emission spectrometers on balloons, aircraft, and selected ground observations in coordination with other experimenters in order to identify constituents and infer concentrations from spectra obtained.

W92-70463 **464-12-00**
Goddard Space Flight Center, Greenbelt, MD.
FAR IR TRACE GAS MEASUREMENT
Igor J. Eberstein 301-286-9779

This RTOP is a continuation of the Measurement of Trace Gases in the Stratosphere program. The study uses the FIRS-2 far infrared spectrometer and telescope payload to measure stratospheric OH, O(3P), H2O2, HOCl, and O3 and H2O isotope ratios. Usually, the spectrometer is supported by a balloon flown out of Palestine, Texas. However, it is also planned to fly the SAO Far Infrared Spectrometer (FIRS-2) on the NASA DC-8.

W92-70464 **464-12-05**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
IR SOLAR ABSORPTION SPECTRA
G. C. Toon 818-354-8259

The objective is to obtain high resolution near-infrared solar spectra from which the abundance of many atmospheric minor constituents can be quantified. From these spectra, recorded at different latitudes in both hemispheres and at different seasons, the abundance of over 25 different gases can be measured simultaneously. These spectra also form an historical archive of the state of the atmosphere and will be re-analyzed as improved spectral parameters and retrieval software become available. First analyses of the data obtained from the measurements made in the course of this research meet the objective of establishing the present compositional state of the atmosphere. Retrieved gas abundances will be compared with previous measurements in order to evaluate trends and also with computer model predictions in order to assess their accuracy. Particular emphasis is being placed on chemical processes of current national and international interest, such as the depletion of the ozone layer. The approach taken to meet the science objective is to measure the spectral absorption of solar radiation by the atmosphere over the entire 2 to 16 microns spectral region using a Fourier Transform Spectrometer, the JPL MARK IV Balloon Interferometer. Measurements have been and will continue to be made from various platforms including stratospheric research balloons, aircraft, sea-level and mountain ground-based sites at locations of widely varying latitudes such as the Arctic and Antarctic regions.

W92-70465 **464-12-06**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
MM AND SUB-MM RADIOMETRY
R. A. Stachnik 818-354-1921

The objective is to improve understanding of Earth's upper atmosphere by balloon-based microwave measurements at millimeter and submillimeter wavelengths. Well-founded concerns that man's technological activities may perturb upper atmospheric balances, particularly those maintaining stratospheric ozone, justify this objective. The general approach is to first determine which measurements are needed for atmospheric research and perform calculations to define which subset of these can be usefully performed by microwave techniques. A field program is then established for those measurements of sufficient value. The field program may involve instrument development or improvement. One important goal of this program is to determine both the capabilities and limitations of microwave techniques so they can be used efficiently in NASA's overall Upper Atmosphere Research Program.

W92-70466 **464-12-15**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
FAR INFRARED BALLOON RADIOMETER FOR OH
H. M. Pickett 818-354-6861

A high resolution radiometer will be employed for stratospheric balloon observations of the hydroxyl radical in the far infrared region. The instrument uses three Fabry-Perot resonators to resolve stratospheric limb emission of OH at 101 cm(exp -1) (99 microns). The resolution is 0.0017 cm(exp -1) to match the width of the stratospheric emission lines. The instrument has the sensitivity for retrieving useful OH mixing ratio profiles between 25 km and 46 km with 3 km vertical resolution. Column density of OH above 46 km is also retrieved. The instrument is compact (0.36 cu m), light-weight (100 kg), and requires low power (45 W) and thus is well-suited to balloon observations.

W92-70467 **464-13-15**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
NDSC DIFFERENTIAL ABSORPTION LIDAR
I. S. McDermid 818-354-3213

The primary objective is to provide long-term records of the atmospheric ozone concentration profiles from both the facility already established at JPL's Table Mountain Facility in Southern California and from the new Network for the Detection of Stratospheric Change (NDSC) facility to be established at Mauna Loa Observatory in Hawaii. These measurements, which will become part of the NDSC database, will aid in the detection of changes in the ozone profile and provide information to help understand such changes. In the short term, these lidars will participate in the Correlative Measurements Program for the Upper Atmosphere Research Satellite (UARS) by making comparative, ground-truth, ozone measurements for the four UARS instruments that will also measure ozone profiles. The approach used to measure ozone profiles is that of differential absorption lidar (DIAL) which uses two laser wavelengths to probe the atmosphere. In the troposphere, a Nd:YAG laser is frequency quadrupled to 266 nm and then Raman-shifted to produce the wavelengths 289 and 294 nm. For stratospheric measurements much higher laser energies are required and these are provided by a xenon chloride excimer laser that operates at 308 nm. Raman shifting of the excimer laser gives the reference wavelength at 353 nm. Two telescopes of 40 and 90 cm aperture are used to collect the laser radiation backscattered from the atmosphere for each of the systems. The stratospheric ozone lidar at TMF has been in routine operation since 1988 and has made more than 350 independent ozone profile measurements. This system has also participated in a number of intercomparison campaigns, culminating in the extremely successful 1989 STOIC campaign, which have proved the quality of the results from this lidar. During 1990 and 1991 a new stratospheric ozone lidar has been under development for inclusion in this program at Mauna Loa. The program goals for FY-92 are: (1) to continue to make measurements of stratospheric and tropospheric ozone profiles on a regular and frequent basis at TMF; (2) to install and bring on-line the new stratospheric ozone lidar at Mauna Loa and to commence a measurement program similar to that at TMF; (3) to use all of the lidars to participate in the UARS Correlative Measurements Program; and (4) to continue to participate in intercomparisons and other developmental activities in support of the NDSC.

W92-70468 **464-13-17**
Goddard Space Flight Center, Greenbelt, MD.
UPPER ATMOSPHERE RESEARCH-OZONE GROUND STATION
T. J. McGee 301-286-5645

The objective is to measure stratospheric ozone and temperature from the ground with a sensitivity sufficient to detect predicted Long-Term Trends. The approach is to measure ozone using a differential absorption lidar. The lidar makes use of XeCl excimer laser. Temperature is measured using both Rayleigh and Raman returns.

W92-70469 **464-13-22**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
NDSC: MICROWAVE INSTRUMENT SUPPORT
W. J. Wilson 818-354-5699

The objective is to support the development and operation of the Network for the Detection of Stratospheric Change (NDSC) station at Table Mountain Observatory (TMO). The TMO station will monitor the amount of ozone and water vapor at different altitudes in the middle atmosphere using ground based, upward looking radiometers operating near 22 and 110 GHz. The 22 GHz water vapor radiometer is being developed and constructed at the Naval Research Laboratory. The 110 GHz ozone radiometer was developed by the Millitech Corporation. These are prototype instruments which are based on proven designs but are individually made for this installation. The TMO station facilities have been designed and constructed by JPL as part of this task. TMO provides a year round, 24 hours per day, operating site with on-site surface weather monitoring and archiving, automated data transfer between TMO and all investigators, and direct on-line access to the radiometer controller operating systems from off-site locations through a modem accessible Local Area Network. Two TMO support containers for the instruments have been completed. JPL personnel provide support for the installation, operation and maintenance of these radiometer systems. The ozone instrument was installed and operated for the O3 intercomparison measurements. Development work included the characterization of an automated calibration procedure performed hourly on the O3 radiometer and the inclusion of a facility status log in the automated data transfer stream. The water vapor instrument is now scheduled for installation in June 1991. In June 1992 it is planned to move the ozone instrument to France for a month of intercomparison measurements. Then in August 1992, the instrument will be moved to New Zealand for six months of ozone measurements. Following these measurements, the ozone instrument will be moved to Mauna Loa, Hawaii. JPL personnel will provide support for packing, shipping and installation of the ozone instrument for each of these moves. The work support and shipping costs are included.

W92-70470 **464-14-00**
Ames Research Center, Moffett Field, CA.
STRATOSPHERIC PROCESSES AND ATMOSPHERIC CHEMISTRY STUDIES
P. B. Russell 415-604-5404

The objective is to increase knowledge of the stratosphere and its exchange with the troposphere, with particular emphasis on processes related to ozone depletion. The approach is to develop advanced instrumentation for high- and medium-altitude aircraft (e.g., ER-2, DC-8) and balloons, design and develop special platforms, as appropriate, design and fly missions that acquire data on phenomena of interest, and use the data to answer questions of current scientific concern. The measurements encompass stratospheric chemistry, physics, and dynamics. This RTOP includes three field campaigns now in the data analysis stage, two campaigns in the planning and execution stage, and

possible future campaigns. Names, aircraft, locations, dates, and goals include: (1) Stratosphere-Troposphere Exchange Project (STEP) (U2 and ER-2, U.S. and Australia, 1984-7, to improve understanding of processes controlling transport across the tropopause and toward the ozone layer); (2) Airborne Antarctic Ozone Experiment (AAOE) (ER-2 and DC-8, Chile and Antarctica, August and September 1987, to explain the cause of the Antarctic ozone hole); (3) Airborne Arctic Stratospheric Expedition (AASE) (ER-2 and DC-8, Norway and the Arctic, January to February 1989, to study the northern polar stratospheric clouds and ozone depletions); (4) AASE 2 ER-2 and DC-8, Alaska, Maine, and the Arctic, October 1991 to April 1992, to improve understanding of heterogeneous radical chemistry and dynamics associated with ozone loss); and (5) AAOE-2 (ER-2 and DC-8, Chile and Antarctica, April to September 1993, to study Antarctic ozone depletion).

W92-70471 **464-14-00**
Goddard Space Flight Center, Greenbelt, MD.
AIRCRAFT STUDIES OF POLAR OZONE
W. Heaps 301-286-5106

This RTOP provides for development and support of instrumentation used in airborne campaigns to investigate the polar ozone hole phenomena. Most of the effort is development of the airborne Raman Lidar and a smaller portion is for theoretical support of airborne campaigns.

W92-70472 **464-14-20**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
MICROWAVE TEMPERATURE PROFILER
B. L. Gary 818-354-3198

The proposed work consists of two parts: (1) use of JPL's Microwave Temperature Profiler instrument MTP/ER2 on NASA's ER-2 aircraft during the ER-2 ozone depletion flights of 1991/92; and (2) completion of construction and installation of JPL's Microwave Temperature Profiler instrument MTP/DC8 in NASA's DC-8 aircraft, and use of the instrument during the DC-8 ozone depletion flights of 1991/92. Data analysis will be performed with both data sets. Both tasks are designed to study atmospheric dynamic phenomena related to polar ozone depletion. Both tasks employ an airborne passive microwave radiometer to measure scans of brightness temperature versus elevation angle, which are converted to profiles of air temperature versus altitude. The altitude temperature profiles are used to infer which altitudes are cold enough to produce polar stratospheric clouds. The altitudes of isentrope surfaces are calculated and presented of various dynamical curtain cross-sections. These cross-sections are then studied for the presence of various dynamical meteorological processes, such as gravity wave altitude oscillations of air parcels.

W92-70473 **464-15-00**
Wallops Flight Facility, Wallops Island, VA.
ROCKET TEMPERATURE SOUNDINGS
F. J. Schmidlin 804-864-1618

The objective is to obtain measurements of atmospheric density, pressure, temperature, and wind using meteorological rocketsondes of the passive inflatable sphere type. The data are used: to enhance our understanding of the processes that control the dynamical behavior of the upper stratosphere and lower mesosphere region (i.e., 30 to 85 km); to monitor temperature trends and to detect atmospheric changes; to verify and monitor data from remote (ground- and satellite-based) measurements; to provide direct measurements of winds for verification of the balance wind derived from the use of satellite retrieved temperatures; and to provide data, as needed, for large vehicle mission trajectory analysis. To maintain a climatological data base of in situ temperature, density, and wind data between 30 to 85 km, a program of inflatable sphere observations designed to up-date monthly climatological records requires a minimum of four launchings/month. Current funding levels enable only an approximate six-month program to be maintained. The winter season, which is highly variable, will be selected for these launchings. An enhancement of the launch schedule will be attempted each July. This information can then be compared with measurements from previous July's beginning with 1969 data to determine whether temperature trends persist. Earlier (unpublished) analysis indicates that a temperature trend of about 0.3 to 0.5 C may exist between 30 to 50 km. The meteorological rocket data record is now 30 years long (although gaps exist beginning about 1984 because of reduced resource availability) and may provide greater confidence in the trend results.

W92-70474 **464-15-01**
Goddard Space Flight Center, Greenbelt, MD.
ABSOLUTE SOLAR UV FLUX AND VARIABILITY
James E. Mentall 301-286-9844

The objective is to improve our understanding of mesospheric and stratospheric chemistry by determining the temporal variability of the sun. The approach is to use measurements of the solar UV spectra obtained by balloons, rockets, and satellites to determine the solar variability over the preceding sunspot cycle.

W92-70475 **464-16-01**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
MULTI-SENSOR BALLOON MEASUREMENTS
O. F. Raper 818-354-2435
(464-12-05; 464-12-06)

Continuing technical, logistical and operational support of stratospheric balloon flights is provided to measure the abundance and altitude distribution of key chemical constituents in the upper atmosphere. Two modular gondola systems can carry multi-instrument packages consisting of several JPL remote sensing instruments, and instruments from other institutions in the U.S. or abroad, configured for a particular scientific purpose. Data obtained on the altitude profiles for a number of chemically coupled species from one or simultaneous flights in the same air mass is used for instrument intercomparison purposes and for the validation of atmospheric chemical models.

W92-70476 **464-18-00**
Wallops Flight Facility, Wallops Island, VA.
ECC O3 SONDES
A. L. Torres 804-824-1618

The objective of this RTOP is to study the vertical distributions of ozone at an Antarctic site during the austral spring period of ozone depletion and at a mid-latitude site in conjunction with satellite overpasses. Balloon-borne Electrochemical Concentration Cell (ECC) ozonesondes are used for the profile measurements. Antarctic soundings are conducted from Palmer Station (65 degrees S) from mid-August to late November. The mid-latitude site is Wallops Island, Virginia (37 degrees N), where soundings are conducted under overpasses of satellite-borne instruments such as NOAA-9 SBUV/2 and SAGE II. A Dobson instrument is used for determining total ozone overburdens. Ozonesonde performance under simulated stratospheric conditions is determined in a laboratory-based flight simulator.

W92-70477 **464-21-00**
Ames Research Center, Moffett Field, CA.
HOMOGENEOUS AND HETEROGENEOUS PROCESSES
E. P. Condon 415-604-6071
(464-14-00)

The objective is to conduct a program of theoretical and experimental research into homogeneous and heterogeneous processes in atmospheric chemistry, with particular emphasis on processes related to ozone depletion. The approach is to perform laboratory kinetics studies to acquire data on reactions and phenomena of interest to assist in the interpretation of results from the Polar Ozone Campaigns. These laboratory data will also provide information crucial to the High Speed Research Program.

W92-70478 **464-21-02**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
CHEMICAL KINETICS OF THE STRATOSPHERE
L. F. Keyser 818-354-3234

A program is underway to determine rate constants and product

yields of atmospheric reactions by laboratory kinetics and photochemical techniques, to develop new experimental methods to detect reactive species under conditions of temperature and pressure occurring in the atmosphere, and to study the physical-chemical properties of atmospheric aerosol surfaces. These studies are carried out by using a discharge-flow resonance fluorescence system interfaced with infrared diode-laser spectrometry and mass spectrometry. Aerosol surfaces are studied by using a static system with infrared diode-laser spectrometry.

W92-70479 **464-21-02**
Goddard Space Flight Center, Greenbelt, MD.
UPPER ATMOSPHERE - REACTION RATE AND OPTICAL MEASUREMENTS
L. J. Stief 301-286-7529

The objective of this RTOP is to measure kinetic rate coefficients of importance to the stratosphere and mesosphere and to develop new optical techniques for detection of atmospheric species. The laboratory effort in chemical kinetics uses existing equipment of unique capability for the purpose of measuring absolute rate constants of reactions of importance in current models of the stratosphere. Rate constants of atom-molecule and radical-molecule reactions are measured as a function of temperature and pressure using the technique of flash photolysis-resonance fluorescence. Rate constants for reactions of atoms and free radicals with both free radical and molecular species are measured as a function of temperature using a discharge flow system with collision free sampling to a mass spectrometer. Intracavity laser absorption is being developed as a complement to both fluorescence and mass spectrometric detection.

W92-70480 **464-21-05**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
HOMOGENEOUS AND HETEROGENEOUS PROCESSES OF ATMOSPHERIC INTEREST
M. T. Leu 818-354-2432

The purpose of this research is to obtain direct measurements of kinetic rate parameters for homogeneous and heterogeneous reactions important in stratospheric chemistry, and to develop new experimental techniques for laboratory study of polar ozone chemistry.

W92-70481 **464-21-06**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
KINETICS OF TROPOSPHERIC AND STRATOSPHERIC REACTIONS
S. P. Sander 818-354-2625

A program of laboratory studies is underway to measure kinetic, photochemical, and spectroscopic parameters relevant to tropospheric and stratospheric chemistry. Attention will be focussed on reactions important in polar ozone chemistry. The experimental approach will utilize several state-of-the-art kinetic techniques including flash photolysis, discharge flow-mass spectrometry and discharge flow-Fourier transform infrared spectroscopy. Part of this effort will include the continued development of a Fourier Transform ultraviolet spectrometer for laboratory and field use.

W92-70482 **464-22-01**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
PHOTOCHEMISTRY OF THE UPPER ATMOSPHERE
W. B. DeMore 818-354-2436

The objective is to conduct laboratory studies of stratospheric photochemistry, including photolytic quantum yields, reaction rates and mechanisms, product distributions, and absorption cross sections.

W92-70483 **464-23-00**
Ames Research Center, Moffett Field, CA.
QUANTITATIVE INFRARED SPECTROSCOPY OF MINOR CONSTITUENTS OF THE EARTH'S STRATOSPHERE
C. Chackerian, Jr. 415-604-6300

Remote and in situ detection and measurement of stratospheric minor constituent species via spectroscopic techniques are being routinely employed to develop a better understanding of this portion of our atmosphere and man's effect upon it. Proper interpretation of these measurements relies strongly on having the correct molecular parameters. The objective of this work is to obtain laboratory measurements of basic molecular parameters, such as rovibrational line intensities and half-widths, absorption band intensities, vibrational and rotational constants, vibration-rotation interaction constants, and line position measurements including pressure induced shifts, as well as to develop new spectroscopic techniques to detect species in question. These parameters, and their dependence on pressure and temperature, will be determined from spectra obtained by using cooled cells, long path gas cells, high resolution interferometers, and tunable diode laser spectrometers. At Laboratoire d'Infrarouge various experimental techniques and new theoretical approaches are being used to obtain and interpret infrared spectra of free radical molecules. Also, in collaboration with Stanford University, the sensitivity of magnetic circular dichroism will be tested for in situ detection of the OH radical via the A to X transition.

W92-70484 **464-23-00**
Goddard Space Flight Center, Greenbelt, MD.
HIGH RESOLUTION UV CROSS SECTIONS
Igor J. Eberstein 301-286-9779

This is an experimental and computational program to study the spectral characteristics of O2, O3, and CO2 in the ultraviolet, and determination of the molecular constants of the commonly occurring isotopes. The 6 m vacuum spectrometer has a resolution of 0.0013 nm. The CO2 spectrum will be measured in the 120 to 200 nm range. The O3 spectrum will be measured in the 356 to 360 micron range. The O2 spectrum is measured in the Shuman-Runge region, including cross sections of the bands at 180 to 195 nm. The pre-dissociation lines of O2 will continue to be measured, and the dissociation energies of O2 will be determined from the absorption spectra at approximately 25K, obtained by a supersonic free-jet expansion technique.

W92-70485 **464-23-08**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
INFRARED LABORATORY SPECTROSCOPY
R. A. Toth 818-354-6860

For the proposed task, high resolution infrared laboratory spectra of stratospheric molecules will be recorded and analyzed to produce linelists of molecular parameters (line frequencies, strengths, widths and lower state energies). The molecules studied will be those minor and trace species of importance in understanding the Earth's atmosphere. The particular spectral regions to be analyzed (2 to 16 microns) coincide with those used by NASA field experiments that do remote sensing by high resolution spectroscopy (ATMOS, BLISS, Mark IV, UARS, EOS and the ground-based network). The laboratory spectra will be recorded at spectral resolutions of 0.0028 cm(-1), 0.0056 cm(-1) and 0.011 cm(-1) with a Fourier transform spectrometer located at Kitt Peak National Observatory. Data reduction and measurement will be performed on the ATMOS Data Analysis Facility at the Jet Propulsion Laboratory (JPL), and modelling of the measurements by quantum mechanics will be done at JPL and elsewhere in collaboration with non-JPL colleagues. Emphasis will be placed on high accuracies for the line frequencies, line strengths, line widths and shifts and on comprehensive analyses of important spectral regions to provide complete spectral informations for atmospheric remote sensing.

W92-70486 **464-23-09**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
LASER LABORATORY SPECTROSCOPY
R. D. May 818-354-3256

The laser laboratory spectroscopy program involves the acquisition and analysis of molecular spectral parameters which are required for the interpretation of data from stratospheric measurements made using infrared spectroscopy, specifically by the Balloon-Borne Laser In-Situ Sensor (BLISS) infrared laser

instrument, the Aircraft Laser In-Situ Absorption Spectrometer (ALIAS), and also the Mark IV and ATMOS FTIR spectrometers. Line positions, absorption strengths, and air-broadening coefficients are the spectral parameters measured, including their dependence on temperature. New spectroscopic techniques for sensitivity enhancement and spectral lineshape analysis are also investigated.

W92-70487 **464-23-10**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
MILLIMETER AND SUBMILLIMETER SPECTROSCOPY IN SUPPORT OF UPPER ATMOSPHERIC RESEARCH
E. A. Cohen 818-354-4701

A program of millimeter and submillimeter spectroscopy research will be conducted in support of upper atmospheric research. This will include laboratory studies and generation of spectral line lists. These will be made available for distribution to the field measurement community via the Jet Propulsion Laboratory (JPL) Microwave Millimeter and Submillimeter Spectral Line Catalog. The program involves the acquisition and analysis of molecular spectral parameters which are required for the interpretation of data from stratospheric measurements. The laboratory spectral measurements will be conducted specifically in support of the JPL millimeter radiometer instruments. Emphasis is placed on accuracy of line frequency, line width, and transition moment measurements, in order to take full advantage of spectroscopic techniques for quantitative atmospheric species measurements. A large portion of the spectral data will also be of value to other groups who use spectroscopic instruments for atmospheric measurements. This will be cataloged in a continuously upgraded millimeter data base and made available to interested users. This program has provided valuable molecular structural information which has direct bearing on proposed mechanisms for polar ozone destruction. The techniques employed have been shown to be uniquely capable of identifying products of ClO reactions. Work in this area will continue with particular emphasis on elucidating the role of the higher chlorine oxides and transient species in upper atmospheric chemistry.

W92-70488 **464-34-00**
Ames Research Center, Moffett Field, CA.
LOWER STRATOSPHERE AIRCRAFT DATA ANALYSIS
L. Pfister 415-604-3183

The purpose of this research is to address several long-standing topics in the dynamics and chemistry of the lower stratosphere, including: (1) tropical and midlatitude stratosphere-troposphere exchange; (2) the stratospheric water budget; and (3) transport within the lower stratosphere. Scientific questions include: (1) What respective roles do tropical convection and regional ascent play in the mass input into the tropical stratosphere?; (2) What are the implications for the stratospheric water budget?; (3) What is the radiation budget of tropical cirrus and what is its importance to mass input into the stratosphere?; (4) What is the importance of turbulence to lower stratosphere transport?; and (5) How important are short vertical scale phenomena to lower stratosphere latitudinal transport? The tasks under this RTOP will address these questions by analysis and modeling of high altitude aircraft measurements taken during a number of recent campaigns, primarily the Stratosphere-Troposphere Exchange Project campaigns of 1984, 1986, and 1987. Data from the Airborne Antarctic Ozone Experiment (1987) and the Airborne Arctic Stratospheric Expedition (1989) will also be used. Measurements include meteorological variables, ozone, nitrogen oxides, water vapor, total water, particle data, carbon monoxide, nitrous oxide, cosmogenic radionucleides, and chlorine and bromine compounds. Auxiliary data (radiosondes, satellite measurements) will also be employed.

W92-70489 **464-34-30**
Goddard Space Flight Center, Greenbelt, MD.
ANTARCTIC OZONE PROJECT
Arlin J. Krueger 301-286-6358

The objective of this RTOP is to analyze the formation of polar ozone minima and to provide Total Ozone Mapping Spectrometer (TOMS) data products in a timely manner to scientific users and agencies, especially while research on Antarctic and Arctic ozone changes is being conducted. The approach is to produce ozone data files and transmittable data sets or graphical products on a next day basis and to analyze the development of ozone minima in relation to meteorological and chemical causes.

W92-70490 **464-41-00**
Goddard Space Flight Center, Greenbelt, MD.
ASSESSMENT AND COORDINATION
Richard S. Stolarski 301-286-9111

An objective of this RTOP is to form committees of leading scientists to evaluate the state of knowledge concerning ozone trends and prepare reports summarizing the present knowledge. The Ozone Trends Panel Report is published. A new UNEP review and assessment has begun. Principal authors have been chosen and an outline of the report approved. The UNEP report chapters will be prepared for review. A review meeting will be held in October, 1991.

W92-70491 **464-41-04**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
DATA SURVEY AND EVALUATION
W. B. DeMore 818-354-2436

An up-to-date tabulation and critical evaluation of kinetic and photochemical data relevant to the stratosphere will be maintained for use by atmospheric modelers, to aid in the establishment of research priorities, and to identify gaps or inconsistencies in the database.

W92-70492 **464-50-00**
Langley Research Center, Hampton, VA.
ATMOSPHERIC PROCESSES/TROPOSPHERIC CHEMISTRY PROGRAM
James M. Hoell, Jr. 804-864-5826

The objective of the RTOP is to develop a basic understanding of the chemistry of the global troposphere and its interaction with the stratosphere, land, and oceans through a coordinated program of atmospheric process modeling, theoretical studies, instrument/technique development, laboratory studies, and measurements from satellite, aircraft, and ground-based platforms. The approach for achieving the objectives will consist of (1) improvements in instrument detection limits for measurement of the very low concentrations of trace gases encountered in the remote troposphere; (2) improvements in response time of measurement systems to enhance our capabilities for coupling chemical sensors to meteorological sensors for improved flux determinations; (3) expansion of measurement techniques; (4) expansion of the range of validity of laboratory measurement techniques to conditions encountered in field measurements; and (5) establishment of reliable absolute calibration procedures for instruments measuring key tropospheric species and intercomparisons of different instruments that can measure the same species in an effort to identify and correct any systematic errors.

W92-70493 **464-51-00**
Goddard Space Flight Center, Greenbelt, MD.
TROPOSPHERIC PHOTOCHEMICAL MODELING
Anne M. Thompson 301-286-2629

The objective of this RTOP is to analyze satellite and NASA/GTE and other field data (from tropospheric missions) to derive ozone budgets in troposphere; to predict perturbations to tropospheric CH4-CO-NOx and O3-OH with a photochemical model: assessment calculations; to perform uncertainty analysis of computed trace gas concentrations and implications for O3 budget and assessment calculations; to use results to plan future GTE missions; to combine modeling and data analysis to derive ozone and other photochemical budgets from detailed study of individual events from field experiments (modeling uses I-D model in coordination with Code 912 cloud model); and to use I-D model for multiple runs based on alternative scenarios and various

chemical environments to evaluate perturbations and uncertainties in ozone and OH.

W92-70494 **464-53-01**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
KINETIC STUDIES OF TROPOSPHERIC FREE RADICALS
S. P. Sander 818-354-2625

A program of laboratory studies is underway to measure kinetic and photochemical parameters involving key free radical reactions in tropospheric chemistry. Attention will be focused on reactions involved in methane oxidation cycle, and the homogeneous mechanisms for the oxidation of non-methane hydrocarbons including isoprene and the terpenes. The experimental approach will utilize several state-of-the-art kinetic techniques including flash photolysis, discharge flow-mass spectroscopy and discharge flow-FTIR spectroscopy.

W92-70495 **464-54-00**
Ames Research Center, Moffett Field, CA.
GLOBAL TROPOSPHERIC EXPERIMENT AIRCRAFT MEASUREMENTS
H. B. Singh 415-604-6769

The objective of this program is to provide atmospheric measurements aboard NASA aircraft to support the science goals of the Global Tropospheric Experiment. The approach is to develop and test airborne instrumentation, integrate it on the aircraft platforms (Electra, DC-8), operate it during Global Tropospheric Experiment flights, provide data as required by Global Tropospheric Experiment project office, and analyze, interpret, and publish individual and/or collaborative results.

W92-70496 **464-54-27**
Wallops Flight Facility, Wallops Island, VA.
ECC SONDE SUPPORT
A. L. Torres 804-824-1553

The objective of this RTOP is to provide vertical profiles of atmospheric ozone at an equatorial site. These data are used to study tropospheric ozone in equatorial regions and for correlative support of satellite-borne ozone instruments. Bi-weekly ozone soundings using balloon-borne Electrochemical Concentration Cell (ECC) ozonesondes will be conducted from Natal, Brazil (6 degrees S, 35 degrees W). The measurements will provide detailed vertical profiles of ozone and temperature as a function of pressure from the ground to about 10 mb.

W92-70497 **464-60-00**
Goddard Space Flight Center, Greenbelt, MD.
LABORATORY FOR ATMOSPHERES GENERAL PURPOSE EQUIPMENT
C. E. Cote 301-286-8406

Much of our existing laboratory equipment is generally slow, manually operated, and non-computer controlled. Although adequate for the 1970's, the equipment started to become a hindrance to our research and development activities in the 1980's, and are totally inadequate for our requirements for the 1990's. Continued involvement in state-of-the-art spaceflight instrumentation cannot be conducted without having the use of advanced laboratory equipment. The use of advanced laboratory support equipment increases efficiency in conducting the laboratory studies and is cost effective by offering more reliability and dependability.

Solid Earth Processes

W92-70498 **465-11-00**
Goddard Space Flight Center, Greenbelt, MD.
UNIVERSITY FUNDED RESEARCH IN SOLID EARTH SCIENCES
David E. Smith 301-286-8671

This RTOP provides funding for university research of the Solid Earth Sciences Program Office.

W92-70499 **465-12-00**
Goddard Space Flight Center, Greenbelt, MD.
SOLID EARTH DYNAMICS
Steven C. Cohen 301-286-8826

The objective of this RTOP is to study the dynamics, kinematics, structure and composition of the solid earth and its constituent parts including the lithosphere, asthenosphere and, as appropriate, the deeper mantle and core; to develop models of compressional deformation of the lithosphere; to develop analytical and numerical models of deformation with plate boundary zones and develop techniques for statistically evaluating a-priori geophysical models; to develop models of strain accumulation and release in fault zones with particular emphasis on the earthquake cycle in subduction zones and the interaction between faults; and to develop mathematical and computation techniques to apply to a wide range of geodynamical geophysical problems.

W92-70500 **465-12-03**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
CRUSTAL STRAIN MODELING USING FINITE ELEMENT METHODS
G. A. Lyzenga 818-354-6920

The objectives of this RTOP are the application and interpretation of numerical models of the time dependent deformation of the earth's crust in active tectonic zones. This research has direct relevance to the interpretation of measurements being carried out in conjunction with the NASA Geodynamics Program. As a scientific investigation, this modeling effort is aimed at answering questions raised by both geodetic and other observations concerning the state of crustal stress and driving forces at plate tectonic boundaries. In this way, the task serves as a theoretical and interpretive complement to the observational information provided by space geodesy. Although the problem of understanding plate tectonic deformation processes is limited by the availability of data, there exist considerable theoretical uncertainties concerning the fundamental physics and distribution of constitutive properties and stresses. The task described in the present RTOP addresses the underlying physical processes giving rise to the observed motions. The approach employed in this task uses the finite element method to construct time dependent models of tectonic deformation in spatially inhomogeneous domains. This approach allows the description of realistic configurations of faults and variable material properties that are not amenable to analytic techniques. These modeling methods have proven useful for gaining insight into the physical processes driving and controlling episodic and steady deformation at plate boundaries. Graphical visualization techniques have proven to be a valuable and important aspect of the modeling process, allowing the display and dissemination of the numerical results, as well as the discovery of important phenomena and trends latent in the simulation results. The specific research goals to be pursued in the following year represent continued progress, building on the successful results of the past year's research. In particular, this will involve the investigation of reverse dip-slip models of the earthquake cycle, relevant to zones of continental convergence as well as oceanic subduction settings.

W92-70501 **465-13-00**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
EARTH STRUCTURE AND GEOPHYSICS
C. F. Yoder 818-354-2444

A wide range of geophysical investigations are proposed. These include: (1) analysis of tectonic processes (brittle/ductile deformation and block rotation along the Pacific-N, American plate boundary zone, and circum-Pacific crustal motions above

subduction zones); and (2) a study of lateral mantle heterogeneity from seismic P and S wave travel time data. The three major research elements covered here are: The first major research element covered is tectonic processes in which an integrated research approach is emphasized, combining quantitative modeling and qualitative synthesis of diverse data types. The tasks include: (1) synthesis of geologic, tectonic, geophysical, and geodetic data to develop kinematic models of block rotations and translations; (2) investigation of block rotation mechanisms; (3) measurement of paleomagnetic declination to determine Mojave block rotation; and (4) application of a strike-slip/thrust fault model to study crustal motions within the Transverse Ranges. The second major research element covered is the Upper Mantle P and S Wave Study in which P and S wave velocity anomalies shall be inverted for lateral variations in elastic parameters (Poisson's ratio, seismic parameter). These variations can be used to infer variations in lateral thermal and compositional structure in the upper mantle. The third major research element covered is subduction zone deformation in which accurate present-day plate convergence velocity estimates along the circum-Pacific trenches shall be compared to the 1000+ subduction earthquake slip vectors presently available. Correlations of anomalous along-trench geologic structures with locally oblique subduction shall be assessed, and model rate estimates for space based geodetic surveys provided. Contributions from plate circuit errors will be assessed, including East Africa rifting and West Pacific microplate kinematics.

W92-70502 **465-13-00**
Goddard Space Flight Center, Greenbelt, MD.
SOUTH AMERICAN NEOTECTONICS
Bruce G. Bills 301-286-8555

The objective of this RTOP is to use vertical crustal deflections recorded in the originally horizontal shorelines of Lake Minchin, a large, late Pleistocene lake situated on the Altiplano of Bolivia, to probe the structure and mechanical properties of the continental lithosphere on length scales of tens to hundreds of kilometers and time scales of decades to millennia. The approach is to: measure present elevations of 30 to 40 locations on each of 5 prominent shorelines; collect samples for laboratory C-14 and Cl-36 age determinations; and model the response of layered viscoelastic half-space to spatially and temporarily varying normal surface load.

W92-70503 **465-13-06**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
ACTIVE DEFORMATION IN THE MOJAVE DESERT AND WALKER LANE: A GLOBAL POSITIONING SYSTEM EXPERIMENT
M. M. Miller 818-354-8820

The objective of this RTOP is to carry out a series of combined static and kinematic mode Global Positioning System (GPS) experiments that will monitor fault motions both within the Mojave Desert and between the Mojave Desert and adjacent areas. These studies will: (1) characterize the role of Mojave faulting in accommodating modern Pacific-North American plate motions; (2) establish new constraints on the relation between tectonism the Mojave Desert and adjacent structural domains; and (3) provide local strain nets that will clarify ambiguities of local displacements around NASA's Crustal Dynamics Project MOJAVE and Owens Valley Radio Observatory (OVRO) base stations. Site location, monumentation, and related field work for the initial phase of the static mode experiment will be conducted in 1991. A local network of sites around the MOJAVE base station that will be occupied in a kinematic mode test experiment will also be located and monumented during this time interval. The first static mode experiment and the concurrent kinematic mode test experiment will be conducted in the subsequent year. Pending results of the test experiment, local kinematic mode networks will be established and monuments will be installed in late 1991 and 1992, and occupied in 1992, in the vicinity of the MOJAVE (reoccupation) and OVRO base stations, and across the Garlock fault. In subsequent years, concurrent static and kinematic mode reoccupation experiments will be conducted on an annual basis, and field studies will focus on characterizing localized deformation detected by the GPS experiments.

W92-70504 **465-14-01**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
GLOBAL TECTONIC MOTIONS
R. S. Gross 818-354-4010

The proposed research is intended to continue the study of present day plate motions using Earth orientation measurements, and the related production of Earth orientation series which account for tectonic motions of the participating geodetic observatories. This RTOP can be divided into two tasks, analysis of publicly available Earth orientation data, and the re-reduction of Infrared Interferometer Spectrometer (IRIS), POLARIS, and Crustal Dynamics Project Mark III Very Long Base Interferometry (VLBI) data at JPL using JPL software. It should be noted that the inherent accuracy of VLBI baseline orientation determinations can be equal to or better than the length estimates from the same baselines. The study of tectonic motions through orientation measurements will both complement the more traditional study of length changes and serve as an important source of new information, without requiring the acquisition of any additional data. The first task will involve the re-reduction of the IRIS/POLARIS VLBI data with an independent JPL software package providing both the length and orientation determinations. The length and orientation of each baseline in the network will be estimated each time it is observed to provide the detailed geodetic results necessary for a complete analysis of network deformation. This task will produce determinations of the velocity of relative motions between Europe and America with formal errors of 1 centimeter/year or smaller from both orientation and length data and will greatly increase the confidence in rate estimates from changes in baseline length. The second task will use publicly available Earth orientation measurements (Satellite Laser Ranging (SLR), Lunar Laser Ranging, and VLBI from other sources - NASA Crustal Dynamics Project and the Deep Space Network) together with baseline orientation results from the first task, to study the slow divergences in the observed Earth orientation caused by plate motions. This task will produce tectonic motion estimates with formal errors of 1 to 2 centimeters/year or smaller from locations on the North American, European, and Australian plates. The resulting drift rate estimates will be compared with geological plate motion models and with other geodetic motion estimates.

W92-70505 **465-14-02**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
GLOBAL SEA LEVEL CHANGES
R. S. Gross 818-354-4010
(148-90-00; 578-32-22)

The fundamental objectives of this study are to: (1) determine improved estimates for the eustatic changes in sea level; and (2) estimate secular and other long period changes in polar ice volume. Our approach is of an interdisciplinary nature and will include the analysis of several geodetic, oceanographic, and meteorological data sets, together with extensive numerical modeling efforts. The various data types include surface temperature and monthly tide gauge data, Earth's rotation and gravitational field data, space geodetic observations of vertical crustal motion, and satellite altimeter results. Improved estimates for the global rise in sea level will be obtained by analyzing tide gauge data directly, and by observing and subsequently interpreting the effects of a changing sea level on the Earth's rotation and gravitational field. In turn, the Earth's rotation and gravitational field data results, as well as observations of vertical crustal motions, will be used to derive new constraints in the post-glacial rebound modeling effort. Better estimates of the amount of melting of the Antarctic and Greenland ice caps, and of the continental glaciers will be computed by recovering and then by interpreting the expected effect of this melting upon the Earth's rotation and gravitational field. Tide gauge data will be used to directly estimate the global change in the level of the seas. Data obtained from space-geodetic observations of the Earth's rotation and gravitational field will be used to indirectly estimate the sea level change through its effect

of changing the Earth's mass distribution and hence rotation and gravitational field. The space-geodetic data will also be used to derive new constraints for use in the post-glacial rebound modeling effort. A decrease in the total volume of the polar ice caps or of the continental glaciers could be an indication of an enhanced greenhouse effect. We will search for the effects of changes in ice volume using, primarily, the time-dependent gravitational field coefficients. We will supplement those data with Earth rotation information.

W92-70506 **465-15-03**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
VARIABLE EARTH ROTATION
C. F. Yoder 818-354-2444

This RTOP is intended to support general scientific research related to interpretation of the Crustal Dynamics Program (CDP) earth orientation data (universal time (UT1), polar motion, and nutation) and Lageos orbit perturbations, particularly the secular changes in J sub 2, J sub 3, J sub 4, etc. The primary topic concerning earth rotation is the construction of a more complex semi-analytic nutation model which takes into account oceans, solid friction, and earth model uncertainties. In addition, the effect of the inner core, core-mantle boundary layer, figure-figure core mantle coupling, and the non-hydrostatic gravity field shall be examined. The principal objective for this task is to determine how well nutations constrain the core-mantle ellipticity, solid friction Q, and earth structural models. A layered earth model has already been developed to examine how viscosity structure and melting history affect present day changes in gravity field. A composite rheology model has been constructed which exhibits transient relaxation and which may be a reasonable model for the spherically symmetric component of mantle heterogeneity. A model describing the lateral dependence on viscosity structure shall be developed which uses the tomographic lateral velocity variations to infer temperature viscosity variations. The principal objective is to determine how well observables such as the secular change in J sub 2, and polar motion constrain viscosity structure. Finally, mechanisms which could account for non-tidal changes in UT1 of order 200 sec on millenia time scales shall be examined.

W92-70507 **465-15-05**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
EARTHQUAKE COSEISMIC EFFECTS
R. S. Gross 818-354-4010

The fundamental objective of this study is to examine the individual and cumulative coseismic effects of earthquakes on global geodetic properties of the Earth. We will study both the long term (century) and short term (decade) changes that occur in these properties, as well as their interrelationships. Our approach will be to first compute the earthquake-induced deformation field of the spherically symmetric, non-rotating, elastic, isotropic (SNREI) Earth model 1066B by expanding the deformation field as a weighted sum of the normal mode eigenfunctions of 1066B. For this calculation, we will use two different earthquake source mechanism data sets, namely: (1) the centroid-moment tensor solutions being routinely determined and published by the Harvard Group for all earthquakes having seismic moment M sub o greater than 10(exp 24) dyne-cm (solutions for more than 8000 earthquakes that have occurred since 1977 are currently available); and (2) the source properties for the greatest (M sub 0 greater than 10(exp 28) dyne-cm) earthquakes to have occurred since 1900 that have been determined and published in the publicly available literature. We will then determine the effect that these earthquakes have had on: (1) the secular drift of the Earth's rotation pole; (2) polar motion; and (3) the Earth's shape as measured by changes in baseline lengths and orientations. We also address whether or not the Earth's polar motion has any influence on the occurrence, particularly the timing, of earthquakes. This will be done through statistical tests using an earthquake catalog consisting of some 8000 earthquakes of magnitude greater than 5 that have occurred since 1977. Two approaches will be pursued, both based upon studying the statistical distribution of the angle between certain angular parameters of the earthquake and the longitude lambda sub m of the pole position at the time of the earthquake: (1) Statistical distribution of delta lambda sub 1 is identical to lambda sub e - lambda sub m where lambda sub e is the longitude of the earthquake epicenter; and (2) Statistical distribution of delta lambda sub 2 is identical to lambda sub psi - lambda sub m where lambda sub psi is the longitude of the polar motion excitation caused by the earthquake.

W92-70508 **465-16-00**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
GPS STRAIN MONITORING IN THE NEW MADRID SEISMIC ZONE
D. M. Tralli 818-354-1835

Large earthquakes in the New Madrid seismic zone (Missouri, Arkansas, Illinois, Kentucky, and Tennessee), such as the great 1811-12 earthquakes, pose a serious hazard to the central U.S. The magnitude, moments, and fault geometry of these events have been inferred using isoseismal data. However, the locations and mechanisms of more recent earthquakes have been used to delineate the seismic zone and to analyze the faulting in the larger post-1960 events. Earthquake recurrence and probability estimates have been derived from historic magnitude-recurrence data. The absence of recent large earthquakes poses difficulties: mechanisms are available only for events with m sub b less than or equal to 5.0, and the recurrence estimates for events with m sub b greater than or equal to 6.4 require significant extrapolations. The seismic zone overlies the Reelfoot rift, a Precambrian to Early Cambrian rift system buried by thick Phanerozoic strata and Quaternary alluvium. Recent seismicity appears related to reactivation of fossil rift-related faults by the current stress field. We have initiated a collaborative research program with Northwestern Univ., Univ. of Missouri, Univ. South Carolina, using Global Positioning System (GPS) geodesy to quantify the rate and distribution of strain accumulation in the New Madrid seismic zone. We will establish and measure a series of geodetic baselines between approximately 25 sites within the New Madrid seismic zone and at more regional distances, with the long-range goal of using bi-annual measurements to determine baseline changes and thus provide quantitative constraints on the regional tectonics, fault zone mechanics, and earthquake recurrence, and for understanding GPS errors such as tropospheric path delays, signal multipath effects, and benchmark stability, and also assessing enhancement of geodetic precision with deployment of ROGUE GPS receivers for improved cycle ambiguity resolution.

W92-70509 **465-17-00**
Goddard Space Flight Center, Greenbelt, MD.
GRAVITY FIELD FROM LASER DATA
James G. Marsh 301-286-5324

The objective of this RTOP is to improve Goddard Earth Gravity (GEM) modeling by using Satellite Laser Ranging (SLR) to support and advance the science objectives of the Lageos 2 Mission. Improved geopotential models for the invariant and time varying potentials will be developed to more accurately model the orbital evolution of near-Earth laser satellites and to support data analyses at a level comparable to the mm precision laser systems of the future. These fields will be especially strengthened for the orbital accuracy needs of Lageos 1 and 2. The SLR tracking data from Lageos 1, 2, and other precisely tracked satellites recorded by a global network of tracking stations will be combined with the existing recently published GSFC GEM-T3 earth gravity model data base. The intent is to augment this existing data base with the new highly accurate global data sets. The general computational approach will be similar to the well tested and documented approach used for the past 10 years at GSFC.

W92-70510 **465-17-02**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
GEOPOTENTIAL TEMPORAL VARIATIONS
J. O. Dickey 818-354-3235

The fundamental objectives of this study are to: (1) use laser range data to Laser Geodynamic Satellite (LAGEOS 1) (and soon to LAGEOS 2), recover the effects of dynamical Earth processes

upon the Earth's geopotential, and interpret these results to gain insight into the Earth's internal structure and shape, and processes that can induce changes in the geopotential; and (2) obtain improved estimates for the amplitudes and phases of the tidal terms, and interpret these results to gain insight into the Earth's anelasticity and aspherical structure. The approach includes the following: (1) modification of a version of GEODYN to obtain temporally varying Stokes coefficients, and exploration of various techniques to accomplish this, such as explicitly obtaining the time-dependent Stokes coefficients, or modeling the effects of the geophysical process on the gravitational field and using GEODYN to search for this modeled effect; (2) use of analytical and numerical models for a variety of geophysical processes in order to both compute the expected effect of these processes upon the geopotential and to interpret the observed temporally varying geopotential results; and (3) the search for correlations between changes in the gravitational field coefficients and changes in the Earth rotation parameters. Any such correlations found will lend greater credence to the time varying geopotential results.

W92-70511 **465-17-04**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
LATERAL VARIATIONS IN SOLID TIDES
E. R. Ivins 818-354-4785

We shall develop models of solid tidal deformation which include the effects of lateral variation in mantle density, rigidity, and compressibility. Complex tidal models have been developed that are to be compared with available Lageos 1 and 2 ranging station data and other data. The comparison may provide a new constraint on scaling relations between the elastic constants and seismically determined data on shear wave and compressional wave velocity anomalies. We intend to provide maps from which local station corrections to tidal Love numbers can be obtained. Corrections to earth rotation and ocean tidal loading shall also be determined.

W92-70512 **465-21-00**
Goddard Space Flight Center, Greenbelt, MD.
CRUSTAL DYNAMICS PROJECT
J. M. Bosworth 301-286-7052
(453-21-00; 579-32-00)

The scientific objectives are to improve the knowledge and understanding of: (1) regional deformation and strain accumulation related to large earthquakes in the plate boundary regions in western North America; (2) contemporary relative motions of the North American, Pacific, South American, Nazca, Eurasian, and Australian Plates; (3) internal deformation of continental and oceanic lithospheric plates, with particular emphasis on North America and the Pacific; (4) rotational dynamics of the earth and their possible correlation with earthquakes, plate motions, and other geophysical phenomena; and (5) regional deformation in other areas of high earthquake activity. In order to achieve these objectives, an extensive measurement program utilizing both Very Long Baseline Interferometry (VLBI) and university operated Satellite Laser Ranging (SLR) is underway. Frequent high-accuracy measurements of baselines between many stations in active areas near plate boundaries are being made to determine regional deformation and strain accumulation. Baselines between a global set of stations are being measured repeatedly to determine relative plate motions. Repeated measurements of baselines between several stations on the same plate are being made to determine the internal deformation of the plate. Polar motion and Earth-rotation variations are derived from daily measurements with a global set of stations in stable locations.

W92-70513 **465-21-20**
Goddard Space Flight Center, Greenbelt, MD.
LASER RANGING DEVELOPMENT STUDY
Thomas W. Zagwodzki 301-286-5199
(453-21-20; 590-31-31)

The long term goal of this RTOP is to develop automated millimeter accuracy Satellite Laser Ranging (SLR) systems. The technical strategy is to use dual wavelength, subnanosecond pulse laser transmitters, and picosecond resolution streak camera technology to remove centimeter level range uncertainties caused by atmospheric refraction effects. We will investigate potential improvements in ranging system accuracy made possible by recent technological advances in the areas of high-speed timing electronics, photodetectors, and streak cameras. Other research areas include acquisition and tracking software and computer algorithms for unmanned operation.

W92-70514 **465-21-40**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
GEOPHYSICAL ANALYSIS AND MODELING OF LLR DATA
J. G. Williams 818-354-6466

The analysis of the lunar laser range data is intended to determine parameters of geophysical and geodetic interest as its final product. These parameters are station locations, their rates, earth rotation, geomagnetism (GM) of the earth, tidal acceleration of the moon, nutations, and the rate and pole of the precession of the earth in space. These determinations will contribute to precision geodesy and the understanding of plate motion, tides, the moments of inertia of the earth, and the earth's interior structure. The continued processing of lunar range data will improve upon the accuracies of these determinations as newer, more accurate ranges are received. The software needs improvements at the 1 to 2 cm level to fully use the 3 cm accuracy of the ranges being received from all three stations. Principal among these improvements are changes in the tidal displacements of the stations for variable Love numbers, solid body pole tide, and ocean loading. Also needed are rapid (diurnal and semidiurnal) ocean-tide driven earth rotation terms and the ability to solve for out-of-phase terms at one-half and one month. Also intended are upgrades in the software for operational efficiency. Solutions of precession and nutation corrections have been published. Other solutions have given a new value of GM (earth). Earth rotation results have been submitted to the International Earth Rotation Service.

W92-70515 **465-21-40**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
THEORY OF GEODETIC TRANSFORMATIONS
J. G. Williams 818-354-6466

Several of the mathematical models which govern the transformations between celestial and terrestrial coordinates were developed more than a decade ago. These transformations are used in the reduction of data by all techniques (interferometric or range laser or radio). The improvements in observational accuracy and data span require the highest accuracy in the models. The assumptions and approximations which these models depend on should be re-evaluated and the models should be improved where needed. The equation of equinoxes needs to be developed to second order. It is presently a first-order expression. Both the geometrical and dynamical evaluation should be done. The adopted expressions for precession and obliquity changes with time do not take into account that the average lunar torque is not quite aligned with the solar torque. This correction is important (estimated at 0.2 mas/yr) and should be made.

W92-70516 **465-22-60**
Goddard Space Flight Center, Greenbelt, MD.
GEOBEACONS
Thomas A. Clark 301-286-5957
(465-22-00)

The objective of this RTOP is to develop a new concept for high accuracy, real time geodetic positioning in regional (smaller than 1000 km) areas. The approach is to: (1) advance the system design to a Phase A/B study level; (2) build prototype demonstration hardware; (3) perform a demonstration experiment; and (4) discuss results with the scientific community, leading to refinement of the methodology.

W92-70517 **465-23-00**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
DOSE EXPERIMENT SUPPORT
R. E. Neilan 818-354-8330

The Dynamics of Solid Earth Science (DOSE) Experiment Support RTOP incorporates the infrastructure and functions necessary to support Global Positioning System (GPS) experiments funded by the DOSE program. The primary objective of the RTOP is to provide a close working liaison with the principal science investigators to ensure solid GPS experiment planning and execution that results in the collection and processing of a reliable, complete data set. This data set includes the GPS measurements, field logs, and any ancillary data required by the investigator (meteorological, water vapor radiometer (WVR), gravity, etc.). The GPS experiments to be supported are expected to be primarily dedicated to regional deformation investigations. However, support for special measurement needs (seafloor geodesy, rapid static, etc.) are also included as a function of the support effort. This support will provide for any or all of the following activities: pre-planning of logistics; reconnaissance; monumentation; site surveys and documentation; experiment planning and network design; coordination; deployment; data delogging; data validation and cataloging; travel planning; customs brokering; maintenance and depoting of GPS and ancillary equipment; procurement of equipment; and site catalog maintenance. The approach to providing GPS operations support has been evolving from a solely in-house capability which began in 1983, to limited service contracting ongoing since 1989. Currently the RTOP is investigating center managed, off-site facilities contract(s) for providing the routine operations support functions. This RTOP also includes a specific task to support the routine analysis of data from DOSE experiments. This task would provide a core of experienced data analysts to work with the principal investigators (PI's). In the same way that the PI's rely on the experience of the field team in the data acquisition phase of the experiment, the PI's will benefit from the knowledge and experience of specialists in data reduction. This will overcome the inefficiency of having each PI learn the data analysis process from the beginning and insure a uniformity in the quality of the results. The plan for FY-92 is to use this task to complete the analysis of the data collected in field campaigns under the RTOP in GPS Geodetic System Development and Deployment, e.g., the Central and South America (CASA), NOCHE, GEOMEX, and Long Valley experiments. As DOSE experiment data is generated, this task would increasingly assume its long-term purpose of providing a core of experienced data analysts to support the PI's of the DOSE experiments in data processing and analyze baseline NASA GPS experiments such as CASA, NOCHE and GEOMEX. The RTOP consists of the following four tasks: management, data acquisition, data analysis, and equipment procurements.

W92-70518 **465-23-00**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
GPS GLOBAL NETWORK
R. E. Neilan 818-354-8330
(465-23-00)

The primary objective of the Global Positioning System (GPS) Global Network RTOP is to coordinate, implement and operate a high precision, highly reliable, international GPS tracking system required to support Dynamics of the Solid Earth (DOSE) program and Earth remote sensing mission. This system will support baseline accuracies of up to 1:10(exp 9); demonstrate continuous reliability and internal consistency; produce accurate GPS ephemerides and ancillary data; contribute to the maintenance of a precise terrestrial reference frame; provide for data collection, processing, interim archiving and accessing; and monitor the status of the network. The total system will also provide the very accurate GPS orbit determination and terrestrial reference frame control required for a number of NASA sponsored ground programs and space-based missions; the Fiducial Laboratory for an International Natural Science Network (FLINN) and DOSE programs are examples of the former; Topographic Ocean Experiment (TOPEX)/Poseidon, Earth Observing System (EOS)-B, and possibly ARISTOTELES are examples of the latter. The implementation of this system will establish the GPS core of FLINN, as well as establish configuration standards for global GPS station densification through the next decade. The system derives synergistic benefits from the GPS global tracking activity already sponsored by NASA (Codes O and EED) in support of TOPEX/Poseidon and by activities of other organizations such as the IAG sponsored International GPS Service (IGS) and Cooperative International GPS Network (CIGNET). A major objective of this RTOP is to coordinate the multipurpose core network with respect to these related networks and expand into a highly organized, integrated, and consistent global network that will provide a broad class of scientific users with very accurate GPS tracking data and products. Intra-NASA coordination (Code O and E) in FY-90 and FY-91 resulted in communication links and assured access to the 6 station network being implemented in support of TOPEX/Poseidon, thus enabling access to the quality GPS tracking data currently being collected at NASA's 3 Deep Space Network stations by the geodynamics community. This coordination will continue in order to add data from the three additional stations as they become operational. However, a substantial core network to support a global geodynamics program (leading to FLINN) ultimately requires up to 30 globally distributed stations. Realization of the expanded network depends on a strong NASA role for continued inter-Agency and international coordination. In order to achieve the objectives, the RTOP focuses on three closely linked tasks: (1) coordination and planning of NASA's global network activities in conjunction with related activities involving other organizations and/or international programs; (2) establishment of NASA's Network Operations Center for GPS which coordinates system implementation, network operations, and Level 0 data handling and validation; and (3) the establishment of the FLINN GPS Analysis Center for rapid and continual precise GPS ephemerides generation, station locations, and universal time and polar motion (UTPM).

W92-70519 **465-23-05**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
GPS GEODETIC SYSTEM DEVELOPMENT
W. G. Melbourne 818-354-5071

The primary objective of this RTOP is to develop geodetic measurement systems, based on the Global Positioning System (GPS), capable of baseline accuracies of 1 cm and 3 mm or better in the vertical and horizontal components, respectively, over distances up to transcontinental lengths. A secondary objective is to reduce the costs of capital equipment, field operations, and data processing by an order of magnitude. These technology advances will enable high accuracy, low cost, and continuous measurements to be made with temporal resolutions of deformation rates ranging from seconds to years and spatial resolutions ranging from 1 km to 1000 km. This RTOP is divided into tasks which address the development of systems for data acquisition, data analysis, and data management. It also includes tasks for the development of integrated GPS-based geodetic systems for particular applications, e.g., the Permanent GPS Geodetic Array and the Seafloor Geodetic System. These systems were formerly developed under separate RTOPs.

W92-70520 **465-25-00**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
SHORT-PERIOD TROPOSPHERIC NOISE IN CONTINUOUS GPS MEASUREMENTS
D. M. Tralli 818-354-1835

An investigation of the level of short-period tropospheric path delay noise in continuous Global Positioning System (GPS) geodetic measurements is planned. A GPS geodetic network yielding measurements with high temporal and spatial resolution can be used as a strain instrument for monitoring crustal deformation. While smaller strain rates associated with regional tectonic processes can be observed by epoch geodetic measurements, problems in fault zone behavior (such as the depth extent of creep), the relationship between creep and rupture, and the distribution of slip on a fault, suggest that continuous monitoring is desirable given the short periods over which deformation signals

may be defined and otherwise aliased. These different geodetic sampling intervals are subject to distinct error sources. Therefore, identifying those GPS measurement errors which may obscure short-term deformation signals is important, as is achieving high resolution in order to avoid aliasing. In addition to short-period tropospheric path delay fluctuations, the amplification of potential GPS signal multipath effects in local networks and the contribution to the short-period noise spectrum also must be considered. Temporal power spectral density (PSD) models of GPS measurement noise will be determined. The crossover frequency at which GPS measurement noise is less than that in high-quality strainmeter measurements will be determined. Different frequency crossovers and smaller relative noise pass bands will be identified, depending on the shapes of the noise PSD's which are determined by the tradeoff between geodetic sampling interval, strain estimate variance, and the level of correlated short-period tropospheric path delay noise. The short-period effects of GPS signal multipath, particularly its amplification in processing dual-band data over local distances, will also be modeled as a further noise contribution which may obscure the interpretation of tropospheric path delays and strain measurements.

W92-70521 **465-27-01**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
WVR HARDWARE AND SCIENCE SUPPORT
M. A. Janssen 818-354-7247

Over the years this RTOP has provided support for water vapor radiometer (WVR) efforts within the Crustal Dynamics Program. In previous years, a main objective was to provide science and hardware support for the J-series WVR's originally developed at JPL and implemented in the Program. In FY-90 a small pioneering effort was begun under this RTOP to explore the feasibility of constructing a new generation of WVR's which would take advantage of the emerging technology of Monolithic Microwave Integrated Circuits (MMIC). Accordingly, a breadboard radiometer was designed and constructed at one of the canonical WVR frequencies (30 GHz) using available MMIC components, and is currently undergoing testing to demonstrate the feasibility of this approach. This technology is ultimately expected to lead to precision WVR's which cost over an order of magnitude less than such conventional approaches as the otherwise highly successful J-series units. In the next year, we would like to continue our effort towards this goal. Near term objectives include the construction of a high-performance MMIC radiometer at 20.6 GHz based on our present work which would serve as an operational prototype WVR, and a study of this circuit to determine the best way to achieve the low cost goals for the production of operational units.

W92-70522 **465-28-02**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
DSN SITE SUPPORT TO MOJAVE BASE STATION
L. E. Butcher 619-255-8222

This RTOP is intended to provide facility, logistical, purchasing, and depot level repair capability to the Mojave Base Station of the Crustal Dynamics Project (CDP), located at the Goldstone Deep Space Communication Complex (GDSCC). The Deep Space Network (DSN) operated for NASA by JPL, through in-place capability at the Goldstone Deep Space Communications Complex, will provide this needed support to the Mojave Base Station. In particular, custodial, HVAC, logistical (parts issue and purchasing), depot repair of modules and test equipment, electrical, test equipment calibration, water and electrical power services will be provided by the DSN to the Mojave Base Station of the CDP. Additionally, through an in-place contract with the Government Services Administration (GSA), supplementary vehicles will be provided as needed to meet observation needs. The needed support and method of providing such support is described in more detail in a Memorandum of Agreement between the Director, Ground Networks Division OSTDS and Director, Earth Science and Applications Division Office of Space Science and Applications (OSSA), dated 28 Feb. 1985.

W92-70523 **465-29-00**
Goddard Space Flight Center, Greenbelt, MD.
SPACECRAFT MISSION STUDIES AND ANALYSES
David E. Smith 301-286-8671

This RTOP supports the planning and analyses of future Earth sciences missions and associated research. Five individual tasks address technical issues and support on Geoscience Laser Ranging System (GLRS), Gravity Probe B, Lageos 3, ARISTOTELES, and Global Positioning System (GPS) studies. The GLRS support requested provides direct support to the Instrument Scientist, including simulation studies: Gravity Probe B support is requested for further simulation studies; Lagoes 3 requests support for the Study Project Scientist and for cooperative activities with the Italian Space Agency group at Matera; the ARISTOTELES support is for studies by the Study Project Scientist; and the GPS support is for analyses involving the combination of laser and GPS data to support future crustal dynamics investigations.

W92-70524 **465-31-01**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
ADVANCED MAGNETOMETER
E. J. Smith 818-354-2248

The objectives of this RTOP are to: (1) operate the helium magnetometer in a scalar mode and demonstrate that it can meet the requirements of future investigations to study secular changes in planetary magnetic fields and to detect crustal magnetic anomalies; (2) evaluate the sensitivity and accuracy of the magnetometer when operated in the vector mode in strong planetary (Earth-like) magnetic fields and to investigate alternative modes of operation to make vector measurements; (3) optically pump helium using an IR laser rather than a lamp excited by an electrodeless discharge and to evaluate the consequences for the magnetometer performance; (4) investigate the possible use of a solid state semiconductor laser in a space flight magnetometer and fiber optics to transmit the pumping radiation between the electronics and sensor; (5) evaluate the magnetometer performance in a hybrid mode in which it alternates (rapidly) between scalar and vector operation; and (6) evaluate the He nuclear precession magnetometer for possible use in space.

W92-70525 **465-32-00**
Goddard Space Flight Center, Greenbelt, MD.
MAGSAT CRUSTAL ANOMALIES: NATURE OF SOURCES AND CRUSTAL STUDIES
Herbert Frey 301-286-5450

The objective of this RTOP is to determine the nature of the sources of MAGSAT crustal magnetic anomalies, including the relative roles of induced, viscous remanent and thermal remanent magnetization. Data will be used in conjunction with other geophysical and geological data to better understand the nature of both continental and oceanic crustal features, especially submarine plateaus, passive margins, continental rifts and other structures. Improved methods will be developed for analysis of MAGSAT and future ARISTOTELES magnetic anomaly data. The approach is to utilize forward modeling to determine the magnetization structure of the likely source bodies of MAGSAT anomalies, and compare the predicted satellite-elevation magnetic anomalies with observed data. The role will be evaluated of thermal remanent magnetization and thermal enhancement of viscous remanent magnetization in contributing to MAGSAT anomalies. Models will be developed of submarine plateaus to determine their continental or oceanic affinity. Models derived from MAGSAT data at ARISTOTELES elevation will be calculated.

W92-70526 **465-33-01**
Marshall Space Flight Center, Huntsville, AL.
SUPERCONDUCTING GRAVITY GRADIOMETER DEVELOPMENT
S. H. Morgan 205-544-7576

The objective of this RTOP is to develop a full vector, three axis superconducting gravity gradiometer for space flight applications. The instrument will be designed to have a measurement sensitivity of 10(exp -4) EOTVOS units (1 EOTVOS

unit = 10(exp -9/sq sec) in an orbital environment and exhibit a measurement time constant consistent with the current requirements of geodynamics research. The final functioning sensor unit will be constructed and tested in a manner consistent with a proto-flight approach to a possible precursor orbital flight test.

W92-70527 **465-34-00**
Goddard Space Flight Center, Greenbelt, MD.
INLAND SEAS - GRAVITY/TIME STUDIES
Jean E. Welker 301-286-2459

The objectives are as follows: (1) to obtain gravity anomaly mapping of the Mediterranean Sea and interpret previous mappings of the Aral, Black, and Caspian (ABC) Seas; (2) to adapt developed techniques for gravity anomaly mapping to monitor and interpret sea level variations with time over the Aral and Caspian Seas for Global Climate Change Studies; and (3) an Earth Rotation Perturbations data base. The approach will be to: (1) apply previously developed gravity anomaly techniques for the ABC Seas to a multi-basin approach to the Mediterranean, with tide corrections (reinterpret existing literature on ABC Seas with newly derived gravity anomaly mappings); (2) separate previously processed data for an absolute level change calibration, produce sea level change history for the Aral and Caspian Seas (using this sea level change history and modification of existing models, do a Global Climate Change study of both the Aral and Caspian Seas in conjunction with existing literature and question the effects on existing GCMs); and (3) observe sea level change history combined with global climate change studies which will serve additionally as an Earth Rotation Perturbations data base.

W92-70528 **465-35-00**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
ARISTOTELES GPS RECEIVER DEVELOPMENT
E. S. Davis 818-354-8644

The objectives of this RTOP are to develop a set of requirements, select a conceptual design and layout the program for acquiring the flight equipment needed to support the scientific objectives of the mission. JPL has been developing GPS receivers for precision ground applications for the last decade. The latest in the series of ground receivers developed at JPL are the Rogue and TurboRogue. For the TOPEX/POSEIDON mission, JPL contracted with Motorola to develop a flight GPS receiver with similar functional characteristics to the ground receivers and with easily achievable performance specifications. Motorola calls this receiver the Monarch. Two flight qualified Monarchs were delivered to the TOPEX/POSEIDON satellite in the spring of 1991. They will operate as a redundant pair. The TurboRogue was also the basis for the conceptual design of the GPS Geoscience Instrument for EOS. At this point, three salient options exist for developing the flight GPS receiver needed for ARISTOTELES: (1) use the Motorola Monarch making only those changes that are necessary to satisfy the interface of the satellite, the reliability requirements of the project, the operational requirements of the mission, and replace components which have become obsolete; (2) upgrade the performance of the Monarch to correct design deficiencies that stem from errors in the details of the ASIC logic; and (3) develop a flight qualified microprocessor that allows the adoption of the TurboRogue signal processing architecture, it's ASIC design, and software. For each option, the cost for an acceptable level of risk will be estimated, and the performance characterized. From this, a decision on the design concept will be made and the process of acquiring the flight equipment initiated.

W92-70529 **465-35-00**
Goddard Space Flight Center, Greenbelt, MD.
ARISTOTELES MISSION STUDIES
G. W. Ousley, Sr. 301-286-8073
(665-06-12)

Studies will be conducted with ESA for a joint NASA/ESA gravity and magnetic field mapping mission (ARISTOTELES) by adapting technology developed during the MAGSAT program. The studies will be based on the MAGSAT concept and will build on the studies completed by APL.

W92-70530 **465-35-00**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
ARISTOTELES GEOPOTENTIAL FIELD RECOVERY
T. P. Yunck 818-354-3369
(465-31-01)

The objectives of this RTOP are as follows: (1) refine the science objectives and determine instrument requirements for gravity and magnetic field recovery; (2) model the Aristoteles gravity gradiometer and supporting attitude instruments; (3) conduct tradeoff studies of different approaches to Global Positioning System (GPS) precise tracking to assess the Aristoteles GPS tracking performance and its contribution to gravity recovery; (4) evaluate the level of external field contamination of measurements of the surface anomaly magnetic field; devise, analyze, and experiment with techniques for calibrating the external field contamination; (5) devise and construct data filters to extract gravity and magnetic field parameters from a synthesis of available sensor data and test these techniques with data from earlier missions such as Topex/Poseidon; (6) conduct experimental studies in lithospheric and mantle geophysics with global geopotential data; and (7) build an analytical and technical foundation for designing successful geopotential missions in the future. Computer modeling and analysis of existing data from satellite and airborne instruments will be used in geophysical studies to refine the Aristoteles science objectives and to formulate hypotheses to be tested with the gravity and magnetic data. A systematic effort will be made to identify suitable data for this activity. Possible sources include Topex/Poseidon, the space shuttle, Geosat and Magsat data, and airborne experiments. System design tradeoff studies will be conducted to maximize the science return with a complementary and cost-effective suite of instruments. The studies will employ modeling of instrument operation and performance, simulation of data products and processing, and covariance studies, for both flight and ground systems, including science, tracking, and attitude instruments. An effort will be mounted this year to evaluate the use of GPS ionospheric measurements and other radio data to calibrate external field contamination of measurements of the surface anomaly magnetic field. Optimal filtering techniques will be devised to extract the highest quality field measurements through simultaneous reduction of mutually dependent data from all sensors.

W92-70531 **465-41-01**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
ERS-1 RADAR PERMAFROST PENETRATION
T. G. Farr 818-354-9057

The objectives of the proposed research are to measure C-band microwave penetration in a variety of natural surfaces in order to better understand the physics of microwave interaction with natural volumes and to support the quantitative interpretation of ERS-1 image data. A second objective is to detect and map subsurface features in arid regions that relate to past climate changes. Areas of interest will include arid regions (north Africa, southwestern U.S., western China, western South America) and a permafrost region (Alaska). Most of the data for the proposed research will be acquired directly by receivers. Therefore, the main requirement on ERS-1 is that the SAR be transmitting at specific times to illuminate the sites of interest. A number of SAR images will also be required in order to make use of active transponders, as ancillary data to assist in location of receivers relative to beam center, to assess the uniformity of target conditions, and to make mosaics of several arid regions. Targets will be located in Egypt, Alaska, and the western United States. Coverage of the sites in several seasons will be required. Measurements will be made of C-band microwave attenuation in soils as a function of soil moisture and structure and in permafrost as a function of season. These data will then be used as input to existing microwave interaction models to improve quantitative interpretation of ERS-1 SAR images. Mosaic coverage will be obtained of several arid regions to support mapping of subsurface features such as drainages and other indicators of past climatic changes. In Alaska, receivers will be used to make a set of measurements in winter and as thawing occurs in the surface layers in the spring. Summer measurements

will be required in the western United States. As access is the main factor affecting scheduling in Egypt, one or two extended expeditions will be required to make measurements at that site.

W92-70532 **465-42-00**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
REMOTE SENSING INVESTIGATION OF THE NEOTECTONIC AND PALEOCLIMATIC RECORD FOR PORTIONS OF THE SOUTHWESTERN U.S.
R. G. Blom 818-354-4681

This RTOP involves a combined neotectonic and paleoclimatic study of portions of the southwest using a variety of remote sensing data sets as a principal input. Specific neotectonic objectives include detailed studies of the Anza-Borrego and Northeast Mojave regions. These areas are important and previous work has revealed that we can make very substantial contributions. We will also investigate the paleo-drainage systems in the Mojave using the regional Landsat Thematic Mapper image database now in hand. The paleodrainages have been dismembered by neotectonic activity; their extent, configuration and timing of disruption have been incompletely documented. Long standing controversies remain which can be addressed with the remote sensing data. In addition, potassium metasomatism is associated with alkaline lake brines. This important metasomatic process is difficult to detect in the field, but is likely mappable using AVIRIS data and evolving exploratory data analysis tools funded by other RTOPS. We will also refine a sub resolution surface change method and use it to measure recent tectonic deformation and further document its applicability to the monitoring of sand dune re-activation, an important indicator of climatic change. Previously a nearly complete set of Landsat Thematic Mapper image data for the southwest was acquired. In addition, we have SPOT, AVIRIS, TIMS and AIRSAR data for selected areas. We have also built up an extensive network of collaborators who are expert in particular areas or topics. Two complementary tasks fund specific information systems research related to geophysical data sets under study here. These combined resources give us considerable leverage in our investigations. For each task the JPL investigator will focus on the geological application of remote sensing data in cooperation with collaborators who are expert in each specific area or phenomena. For example, for our potassium metasomatism study, we have enlisted the help of a member of the New Mexico Bureau of Mines. We have obtained AVIRIS data for his principal study area in New Mexico to use as a control, and for areas we suspect to be metasomatized in California. He is providing laboratory analyses and assistance in the field. We are thus able to address a problem with expertise and resources not available just under the scope of this RTOP. We employ a comparable procedure for each aspect of our study.

W92-70533 **465-42-00**
Goddard Space Flight Center, Greenbelt, MD.
EAST AFRICAN RIFT TECTONICS AND VOLCANICS
James R. Heirtzler 301-286-8364

The objective is to study the overall geologic and tectonic structure of the East African Rift using remote sensing imagery and other digital geophysical data. This project could set the standard for using remote sensing imagery to study large, geologically interesting parts of the Earth, and so serve as a prototype for studies of EOS data. The approach is to obtain general remote sensing imagery of all of the Rift, from 30 degrees north to 20 degrees south, and detailed imagery of significant parts of the Rift as funds permit. A digital AVHRR mosaic has already been obtained (one image of this used in the 1991 National Geographic Atlas) and selected TM and SPOT have been obtained and will be obtained for detailed study, especially in the AFAR and Southwest sections of the Rift. Both the Marathon Oil Company and CONOCO are interested in supporting this work and the method of doing this is being considered by the GSFC legal office. However, some support is still required from NASA.

W92-70534 **465-42-05**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
APPLICATION OF REMOTE SENSING IMAGERY TO TECTONIC PROBLEMS IN NORTHEAST AFRICA AND THE RED SEA REGION
T. H. Dixon 818-354-4977

The objectives of this RTOP are as follows: (1) understand processes and rates of late Precambrian continental evolution and growth in Northeast Africa-Arabia; (2) relate these processes to other Late Precambrian sections around the world; (3) understand development and evolution of Tertiary-Recent Red Sea rift in context of a propagating rift model in heterogeneous lithosphere; and (4) evaluate utility of various remote sensing data sets in the region for attacking the above problems. The approaches are listed as follows: (1) generate regional image mosaics; (2) obtain, process and interpret detailed remote sensing images in key areas; (3) perform field mapping and ground verification studies in selected areas; and (4) generate quantitative models constrained by above data.

W92-70535 **465-42-06**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
APPLICATION OF REMOTE SENSING IMAGERY TO NEOTECTONIC PROBLEMS IN THE BAJA CALIFORNIA PENINSULA
M. M. Miller 818-354-8820

The objectives of this RTOP are as follows: (1) to understand the modern and recent kinematic framework of tectonic evolution of the western North American plate margin, specifically at the latitude of Baja California; (2) to resolve questions concerning the transfer of slip from spreading ridge-transform systems in the southern Gulf of California to offshore fault systems in southern California; (3) to generate a data base that elucidates the evolution of the Gulf of California and related deformation over the last approximately 5 million years; and (4) to provide constraints for NASA supported geodetic studies in Baja California by identification and study of active faults. The approaches to accomplish this RTOP are as follows: (1) purchase, process, and interpret LANDSAT Thematic Mapper images for the Baja California Peninsula; (2) pinpoint areas of neotectonic activity and supplement the TM data base with SPOT data; (3) carry out geologic mapping and related field studies in areas defined by 1 and 2; and (4) interpret results in the context of the regional tectonics of western North America.

W92-70536 **465-43-00**
Goddard Space Flight Center, Greenbelt, MD.
GEOLOGICAL STUDIES OF THE CANADIAN SHIELD WITH ERS-1 AND AIRBORNE IMAGING RADAR
Paul D. Lowman 301-286-7520

Several major tectonic problems with global implications have been under investigation as part of a Shuttle Imaging Radar (SIR-B) experiment: nature of the Grenville and Nelson Fronts (supposed sutures), origin of regional fracture systems, and origin of major dike swarms. The SIR-B experiment was completed, but served as the foundation for a Canadian-American Environmental Research Satellite (ERS-1) proposal, accepted by ESA. Its objectives are similar to those of the SIR-B experiment, with the addition of an investigation of the origin of the Sudbury Basin by determination of its original shape and size. Imaging radar data from ERS-1, expected early in FY-1991, will be studied to assess its value and the best methods for using it. Various enhancement techniques developed in the course of the SIR-B experiment will be tested, and new techniques tried. Since ERS-1, unlike Shuttle missions, will be a long term satellite, this work will continue for several years. During the evaluation phase, ongoing geologic studies cited under objective will continue, using simulated orbital radar acquired by the Canada Centre for Remote Sensing. Field work will be carried out as possible, and data and results will continue to be exchanged with Canadian colleagues on the ERS-1 team. Radar data from Magellan will be compared with ERS-1 data when it becomes available. Results of the ERS-1 investigation

will be utilized, as were those of the SIR-B study, in a long term study of the origin of continental crust.

W92-70537 **465-43-02**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
MASS BALANCE OF SOIL EVOLUTION ALONG CLIMATE GRADIENTS
O. A. Chadwick 818-354-6229

The objective of this research is to develop datasets that will allow prediction of the response of soil processes and their resulting properties to climate change. Most soil processes leave their imprint on the geologic substrate over relatively long periods of time that do not allow in situ measurements of the actual processes. The practical approach to understanding the role of climate change on pedologic processes is to develop time/climate matrices following the chrono-climosequence concepts to quantify soil properties and infer the time/climate processes that underlie the changes in properties. The approach is to focus on elemental and mineralogical gains and losses which will emphasize the essential connections among the pedological, hydrochemical, geological, and atmospheric environments. Chemical elements such as carbon, nitrogen, phosphorus, potassium, calcium, silicon, and aluminum will be used as tracers in a mass balance analysis that provides functional relationships among soil chemical composition, bulk density, and volume change in relation to parent material. These analytical functions are based on the principle of conservation of mass and include terms that quantify the cumulative deformation during soil development and the mass flux in/out of the soil and between horizons. In addition to documenting deformation and mass flux during pedogenesis at different times during the evolution of soils developing under different climates, we will quantify the elemental distribution among: (1) mineral, noncrystalline inorganic, and organic phases, and (2) particle size separates. The purpose of this effort will be to document the rates at which primary minerals are weathered and the types of secondary mineral synthesis that occur under different climate regimes. The primary geographic/geomorphic areas covered by this research will be (1) marine terraces along the Pacific coast of Oregon, California, Mexico and New Zealand, (2) lava flows on the Island of Hawaii, (3) glacial deposits and fluvial terraces in the Basin and Range and Rocky Mountains, and (4) Queensland, NE Australia. Each of these sites provide important climate gradients, parent material uniformity, and geographic diversity. The level of emphasis for each area will be determined during preliminary field investigations.

W92-70538 **465-43-03**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
MULTISPECTRAL ANALYSIS OF THE STRATIGRAPHIC/STRUCTURAL RECORD, SW MEXICO
H. R. Lang 818-354-3440

The primary objectives are to: (1) refine the geological understanding of the formation and evolution of the southern margin of the North American plate in the Guerrero-Morelos basin region of SW Mexico; (2) evaluate the utility of remote sensing conducted at visible-thermal infrared wavelengths combined with topographic data for mapping strata, defining stratigraphic sequences and modeling facies, and delineating geologic structures and inferring tectonic regimes; (3) integrate lithostratigraphic and structural information from remotely sensed and topographic data with that obtained from conventional field geological and geophysical data using the IGIS workstation; and (4) use results to test available and develop new models of Mesozoic terrane accretion/plate interaction along the southern edge of the North American plate. The approach is to acquire, coregister and analyze remote sensing data from satellite and aircraft systems and conventional data to: (1) define stratigraphic and basement units, map facies and determine their physical, chronological and mineralogical attributes in order to infer environments of deposition and paleogeography; and (2) map structure in order to infer tectonic evolution. A final product will be an east-west crustal traverse through the region of study representing a testable model for lithospheric formation and evolution of the southern edge of the North American plate in the SW Mexico study area. Field and laboratory studies will be performed to support interpretations.

W92-70539 **465-43-04**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
SEDIMENTARY BASINS: CRUSTAL MODELING
J. E. Conel 818-354-4516
(465-43-02)

The objectives of this RTOP are listed as follows: (1) investigate connections between long profiles of major streams in Wind River and Bighorn Basins and present and past climate regimes; (2) formulate theoretical models describing time dependent longitudinal profile evolution, constraining parameterizations of sediment transport and climate connections by analysis of the profiles themselves as well as modern river observations; (3) map along Wind and Bighorn Rivers the most recent changes in channel geometry and incision using Thematic Mapper (TM), Systeme Probatoire d'Observation de la Terra (SPOT) and aerial photos as map bases; (4) provide interpretations of these profiles in terms of the theory of (3); and (5) investigate use of benchmarks in the National Geodetic Satellite (NGS) vertical control network along traverses from Yellowstone Park to Wind River and Bighorn Basins using Global Positioning System (GPS) receivers to discern changes in elevation since early surveys as a means of assessing regional tilt from Yellowstone uplift. This work represents a continuation of past studies on origins of river terraces in Wind River Basin. This stage will aid interpretation of the observed terrace relationships in terms of climate variables as opposed to regional tectonic deformation. The investigations will involve theoretical hydrological models of stream evolution, the parameterization of hydrologic (climatic) variables, and observations of recent datable changes in channel geometry of Wind and Bighorn Rivers. Potential regional tilt from Yellowstone uplift may require assessment. This problem will be assessed from the standpoint of a simple resurvey program with Global Positioning System (GPS) techniques extending to the southeast from the well-surveyed uplift region of Yellowstone Park and following established first and second order traverses of the NGS vertical control network.

W92-70540 **465-43-05**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
SEDIMENTARY BASINS: STRUCTURAL EVOLUTION
E. D. Paylor, II 818-354-2867
(465-43-04; 465-43-03)

The primary objectives of this RTOP are to: (1) better constrain the tectonic evolution of the Mesozoic-Cenozoic continental margin exposed in the Diablo and White/Inyo Ranges, California (representing subduction zone and magmatic arc regions of convergent continental margin respectively) and generalize results to constrain the regionally operative process of continental growth; (2) constrain dynamic models of the Laramide foreland by determining the kinematic evolution of structures in the Wind River and Bighorn Basin region of central Wyoming; and (3) develop and demonstrate methodologies for the combined use of conventional geologic, topographic, and remote sensing methods for detailed analysis of geologic structures. The approach is to: (1) acquire and coregister remotely sensed data from orbital and airborne systems in order to more accurately define, subdivide, and determine internal structures of lithologic units; (2) collect samples for detailed mineralogical, chemical, and spectral characterization of these units and to support the analysis of image data; (3) determine regional and local structural relations (hitherto unobtainable using conventional field based methods alone) in order to decipher the tectonic evolution of each area; (4) conduct field studies to acquire structural data in support of image interpretations; and (5) publish results.

W92-70541 **465-44-00**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
VALIDATION OF VOLCANIC PLUME MODELS WITH REMOTE SENSING
S. M. Baloga 818-354-2219

This interdisciplinary study combines elements of volcanology,

C-2

theoretical modeling, and remote sensing to validate contemporary models of buoyant volcanic plumes. The primary objectives are to: (1) improve the understanding of volcanic ash and gas injection into upper atmospheric transport and dispersal regimes; (2) determine and delineate the limits of validity of classes of theoretical models currently used by the volcanologic science community; (3) demonstrate the usefulness of simultaneous visible, UV, and IR measurements on buoyant volcanic plumes, large scale fumaroles, and industrial analogs; and (4) develop methodologies needed to support large scale volcanologic initiatives such as Earth Observing System (EOS). One phase of this research will focus on the acquisition of data for critical plume variables (width, velocity, temperature, density, particulate concentration) as a function of height above the source. Data acquisition will begin with the study of well characterized industrial steam plumes and progress to sources of volcanic origin. The main thrust of this research will focus on comparisons of plume data with theoretical models for the evolution of these variables and a characterization of the adequacy of the physical description. The theoretical models to be used for this data/theory comparison will be used on extensions of the Morton system of equations for volume, momentum, and density. Regimes of validity of such models will be characterized by standard fluid dynamics parameters such as the Reynolds and Richardson numbers, the buoyant frequency, and other parameters associated with vent conditions.

W92-70542 **465-44-01**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
MEASUREMENT OF VOLCANIC GASES
J. A. Crisp 818-354-9036

Volcanic gas emissions can have an important impact on atmospheric chemistry and greenhouse warming. Efforts to monitor these gases and to assess their global climate impact by remote sensing are seriously hampered by the lack of a complete and accurate database of molecular line parameters for all volcanic sulfur species. The absorption line parameters required are the positions, intensities, transition lower state energies, and line shapes. We propose to compile such a supplemental database that includes the important volcanic gases not available in the 1991 high resolution transmission molecular absorption database (HITRAN) or GEISA compilations. Existing published results will be converted to the HITRAN database format and new laboratory studies for important sulfur carrying species will be undertaken. The resulting supplemental database will be described in a technical report. With HITRAN and the new supplemental database as input for a radiative convective model, the greenhouse warming potential of a large volcanic eruption will be studied and accuracies and detection limits will be determined for measurements of volcanic gases by remote sensing instruments. High resolution laboratory spectra will be recorded in the 1.2 to 12 micron region using Fourier transform absorption spectrometers to provide reference data. Previously published studies on absorption features for all of the important volcanic gases over the 1 to 12 micron wavelength range will be reviewed and validated using the new spectra, and new predictions will be done to form the supplemental molecular database of volcanic species. Portions of the laboratory spectra will be measured as needed for at least two of the four important sulfur species. In particular, detailed measurements and quantum mechanics analyses will be performed to derive line intensities and line shape parameters of prominent OCS and H2S bands. With the absorption line database as input for a radiative convective model, the greenhouse warming potential of a large volcanic eruption will be studied. Radiative transfer calculations will be used to determine detection limits and accuracies for measurements of each of the volcanic gases by instruments on Earth Observing System (EOS) and Upper Atmospheric Research Satellite (UARS) platforms.

W92-70543 **465-44-01**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
REMOTE SENSING OF ACTIVE AND RECENTLY ACTIVE VOLCANIC FEATURES
D. C. Pieri 818-354-6299

Under this RTOP we request support to continue acquisition and analyses of multispectral data on active and recently emplaced volcanic features and related aerosol and gas emissions across a variety of wavelengths from UV through short and long wavelength thermal infrared, and radar (e.g., Ultraviolet Spectrometer (UVS), Airborne Visible and Infrared Imaging Spectrometer (AVIRIS), Thematic Mapper Simulator NS001, Thermal Infrared Multispectral Scanner (TIMS), Thematic Mapper (TM), Thematic Mapper Simulator (TMS), SPOT, Zeiss, Synthetic Aperture Radar (SAR), and Inframetrics 525). We are investigating the relationship between remotely acquired data and the spectral-physical characteristics and processes of active and emplaced volcanics (e.g., composition, surface texture, formation parameters). Underway currently is a 'morphology process model spectral' comparison of Hawaiian and Italian volcanic shields and constituent flows including analyses of thermal data from active lava flows, and morphological and spectral analyses of the Carrizozo Malpais in New Mexico, Mount St. Helens, and the Kliuchevskaya Shield in Eastern Kamchatka, USSR. We are drawing on data and techniques already acquired and proven by the JPL Geology Group and on ongoing work and accomplishments under this program in theoretical and applied volcanology. In particular, we are paying special attention to (high temperature) radiometry of active lava flows and lava ponds at short infrared wavelengths (1 to 3 micron) as well as in traditional thermal bandpasses. We are proceeding to implement these techniques from satellites and aircraft to address basic volcanological problems (e.g., thermal budgets of active lava flows), and look forward to extend insights toward global habitability and societal risk concerns, particularly with regard to high energy explosive eruptions. In addition, under this RTOP support is requested for continuing participation, planning and execution of a cooperative volcanology and remote sensing program with the Institute of Volcanology (USSR Far Eastern Academy of Sciences) *under the US-USSR bilateral space science accords.*

W92-70544 **465-44-02**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
EVOLUTION OF VOLCANIC TERRAINS
M. J. Abrams 818-354-0937
(465-44-01)

The long range goals of this study are to: (1) develop weathering histories of lava flows along strong rainfall gradients to infer climatic influences; (2) study and date cinder cones and maars to determine effects of climate on volcanic landforms, and correlate with glacial chronology; (3) determine the thermal characteristics of active volcanic phenomena, such as lava tubes, domes, and lava lakes to assess thermal budgets and understand dynamics of lava emplacement; and (4) identify and map collapse structures to determine occurrence and frequency of past lateral blast events which may have perturbed climate. Our approach is to combine modeling, processing and interpretation of aircraft and satellite image data, field measurements and mapping, and laboratory studies to address the objectives. In Hawaii, we will combine Digital Elevation Model (DEM) data with aircraft data to determine the effects of varying climate on single flows, using elevation controlled rainfall gradients to examine weathering effects. We will use Thermal Infrared Mapping Spectrometer (TIMS) and NS001 data to study the thermal dynamics of lava tube systems to estimate heat losses of flow fields and better understand flow dynamics. In Mexico, we will use Thematic Mapper (TM) data and field work to map and date a field of cinder cones and maars to determine the interaction of lake and water table levels on landforms; we will correlate the volcanic chronology with glacial chronology to determine paleoclimate of the Serdan Basin. We will continue collaboration with Kamchatka volcanologists to study the occurrence of lateral blasts and climatic perturbations emanating from Kamchatka. We will begin photointerpretation studies of Lake Turkana, Kenya to examine the relationship between climate, lake and fan formation, volcanism, and tectonics in the East African Rift with Duke University.

W92-70545 **465-44-03**
Goddard Space Flight Center, Greenbelt, MD.
MID-OCEAN RIDGE VOLCANISM IN SW ICELAND
James B. Garvin 301-286-6565

The subaerial expression of mid-ocean ridge (MOR) basaltic volcanism occurs uniquely in the Reykjanes region of SW Iceland. This project is intended to explore the various volcanic eruption styles by means of advanced remote sensing techniques and petrologic data. The prime emphasis will be on the causes for variations in lava flow morphology, on the fracture mechanics of tectonic fissures, and on the origin of small Icelandic lava shields. The synergisms of airborne laser altimetry Synthetic Aperture Radar (SAR) and thermal infrared (IR) will be explored. Airborne laser profiles of the microtopographic characteristics of the most youthful lava field in SW Iceland, together with DC-8 Synethetic Aperture Radar (SAR) and ground observations, will be used to quantify variations in surface texture, deformation wavelengths, and to assess lava yield strengths. Comparisons with data for older flows related to lava shields and with lavas on Surtsey will be investigated.

W92-70546 **465-44-10**
Goddard Space Flight Center, Greenbelt, MD.
VOLCANISM - CLIMATE INTERACTION RESEARCH
Louis Walter, S. 301-286-2538

The goals are to expand understanding of (1) volcanic processes, and (2) the effect of explosive eruptions on regional and global climate. Objectives are (1) quantitative determination of volcanic SO2 emissions and dissipation, (2) to assess the effect of volcanic SO2 on climate parameters, and (3) to define requirements for future sensors and missions for SO2 measurements. The approach used will be as follows: to improve empirical algorithms for quantifying low levels of SO2 emissions; to establish accuracy of SO2 measurements using the Total Ozone Mapping Spectrometer data through comparison with data from ground and aircraft measurements; to model SO2 volcanic emission as a function of tectonic setting and petrology of volcanoes; and to define future sensor/system requirements based on observational characteristics determined in this study.

W92-70547 **465-46-00**
John C. Stennis Space Center, Bay Saint Louis, MS.
DELTAIC EVOLUTION (COLD FRONT AND GEOMORPHOLOGY)
Douglas L. Rickman 601-688-1920

With existing data and data acquired within this project, three primary events are being studied. These are the buildup of the Atchafalaya River delta, the impact of cold front passage on sediment transport, and the growth of the Chenier Plain. These will be done by quantitative analysis of morphologic changes as seen in the remotely sensed data, and by comparisons of the ground observations with satellite records of cold front characteristics. This research project has obtained detailed imagery which documents the beginning of permanent deposition of a new delta for the Mississippi River. These data will lead us to a detailed quantification of the large scale processes involved in delta growth. These in turn will be used in developing and testing a numeric model describing the evolution of a delta. Airborne data acquisition has continued this year with concurrent field efforts. A sequential deposition of layered and sorted sediments has been identified on the Chenier Plain. This has not previously been observed and is not reported in the literature. This process has been correlated with specific winter storm events. The resulting deposits appear to be a quite distinct phase in the depositional sequence. The resulting deposition can be identified in the airborne imagery and large scale mapping of the phenomena has begun. The sediment going into Atchafalaya Bay has almost completely filled the original volume of the Bay. Minor changes in water flow and sediment distribution have resulted. For example, the long shore current has begun to significantly control the morphology of one side of the delta. It is expected though that sometime in the next 1 to 3 years a major change in the observed patterns will occur as the Bay finishes filling.

W92-70548 **465-46-01**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
DESK TOP GEOLOGIC ANALYSIS SYSTEM
B. McGuffie 818-354-3116
(465-43-03)

The primary objective of the research is to complete development of the Interactive Geologic Interpretation System (IGIS) desktop geologic analysis system that cohesively incorporates personal computer (PC) hardware and software components for image processing and geologic analysis of combined remotely sensed and digital elevation data. In support of the NASA Multispectral Analysis of Sedimentary Basins project, the Interactive Geologic Interpretation System was developed on mainframe computers for use with Landsat Thematic Mapper (TM) or other digital remote sensing image and digital elevation data. To complement conventional geologic mapping techniques by using computer imaging, graphics, and Computer Aided Design/Computer Aided Manufacturing (CAD/CAM) tools, IGIS provides capabilities for photogeologic interpretation, strike/dip determination, cross section construction, stratigraphic section measurement, topographic slope measurement, terrain profile generation, rotatable 3-D block diagram generation, and seismic analysis. To move the remaining IGIS code to the Macintosh computer desktop environment, the following approach will be used: (1) collaborate with the Geology and Multimission Image Processing Groups at JPL to ensure the finished product is complete as required, (2) add remaining photogeologic interpretation code to the existing IGIS geological applications program, (3) modify existing Fortran code to the 'C' language, (4) produce user documentation, and (5) deliver code to COSMIC.

W92-70549 **465-52-00**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
CHARACTERIZATION OF QUATERNARY GEOLOGIC SURFACES USING MULTIPARAMETER AND INTERFEROMETRIC RADAR DATA
D. L. Evans 818-354-2418

The goal of this research is to facilitate large scale mapping of the composition and morphology of the Earth's surface using multiparameter synthetic aperture radar (SAR) data alone and in conjunction with other sensors. The investigations will focus on the spatial and temporal response of the land surface to climate change. The specific objectives of the research proposed here are to: (1) expand on previous work to identify signatures in remote sensing data which relate geological parameters to process-response models of landscape evolution; (2) develop tools for derivation and analysis of high resolution (1 m) topographic information using radar interferometry data from airborne and spaceborne platforms; and (3) generate a regional synthesis of aeolian patterns which can be used to constrain models of Quaternary climate change in the arid southwestern United States. Analysis of SAR data through quantitative analysis of radar backscatter will be the main thrust of the research proposed here. Visible, near infrared and infrared data sets will be used to fine-tune models of landscape evolution and resolve ambiguities that may remain after the SAR data analysis. The data to be analyzed were acquired in the Mojave Desert of California as part of the Geologic Remote Sensing Field Experiment (GRSFE). The sites to be studied include several centers of volcanic activity, active playas, alluvial fans, and aeolian landforms such as dune fields, desert pavements, and sand sheets.

W92-70550 **465-66-00**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
TIMS MANAGEMENT AND SCIENCE SUPPORT
A. B. Kahle 818-354-7265

The overall objective of the RTOP is to support and promote thermal infrared remote sensing through the use of the Thermal Infrared Multispectral Scanner (TIMS). This effort incorporates the following tasks: (1) overall management and science support; (2) mission planning and coordination; (3) data processing and analysis support; and (4) monitor and document the performance and calibration of the instrument. TIMS is scheduled to be used by

investigators in MAC Europe in the summer of 1991, many of whom have not used TIMS data before. In addition, the RTOP will support EOS investigators, including, at a minimum, ASTER, MODIS plus IDS team members. Finally, this RTOP will support investigators in the SRT programs. Many first-time users of TIMS data require algorithm support to overcome the ambiguities inherent to thermal infrared radiance measurements, which are functions of both temperature and emissivity. This task will include: (1) the management of the science interface between users and operators; (2) the design, verification, and documentation of data reduction and analysis algorithms; (3) the support of laboratory and field spectrometer use by TIMS investigators; (4) monitoring and acceptance of TIMS performance; and (5) in-flight calibration exercises. This task also includes science mission planning which incorporates: (1) furnishing a point of contact for the TIMS investigators; (2) providing information regarding TIMS scheduling and status; (3) providing assistance in the planning of missions, if so asked; (4) maintaining a library of operator logs and flight reports; and (5) maintaining a library of color prints for browsing.

W92-70551 **465-66-00**
John C. Stennis Space Center, Bay Saint Louis, MS.
TIMS CONFIGURATION MANAGEMENT
G. R. Meeks 601-688-1935

The objective is to promote thermal infrared remote sensing through the use of the Thermal Infrared Multispectral Scanner (TIMS) by providing configuration management of the TIMS system. Configuration and calibration control of the TIMS is required to establish and preserve the scientific integrity of the TIMS data. The TIMS sensor system data value is a function of the calibration and performance exhibited by the system during the period the data was collected. In order to provide maximum scientific value and accuracy, appropriate measures designed to determine and distribute system calibration and performance information to the investigator are required. This information should be made available in a timely manner. It should also be available to secondary users of the data. Establishment of a configuration management plan for the TIMS system is under development. The FY-91 version of the plan will include a draft of a multi-center Configuration Control Board charter and definition of field, laboratory, and CCB controlled maintenance and repair responsibilities. A revised FY-92 version of the configuration management plan shall be generated and distributed. A meeting shall be scheduled to provide an opportunity for the members of the CCB to meet and discuss issues relevant to the TIMS configuration. Modifications and changes to the calibration procedures, a process for review by the CCB when necessary, and documentation, distribution and archival of these TIMS activities shall be accomplished. A process for engineering drawing file configuration and control shall be developed and implemented in accordance with standard engineering practice.

W92-70552 **465-67-00**
Goddard Space Flight Center, Greenbelt, MD.
AIRBORNE LASER ALTIMETRY DEVELOPMENT
J. L. Bufton 301-286-8591
(465-67-03; 463-11-15)

The objectives are to develop the technology and techniques of laser remote sensing of Earth surface topography from aircraft and spacecraft platforms; and to provide the laser altimeter instrument capability and operational support for airborne topographic science field missions to meet the science requirements and data acquisition objectives of the NASA Geology Program. Research and development activities involve the improvement of later altimeter instruments and the use of laser altimeter instrumentation in airborne science investigations. Laser altimeter instrument components under development include state-of-the-art diode-pumped solid-state laser technology, sub-nsec timing and digitization electronics, and microprocessor-based data acquisition and storage systems. Development and operational deployment of an airborne laser altimeter system is the prime method of introducing and evaluating new technology for its scientific merit. The airborne laser altimeter system is configured for operations on the NASA Wallops Flight Facility T-39 and P3-A aircraft with a baseline capability of range profiling at nadir with sub-meter vertical resolution and meter-level horizontal resolution for aircraft altitudes to 10 km. The airborne laser altimeter instrument is maintained in an operational state as a testbed for technology improvements and as a data acquisition platform for NASA Geology Program field missions. One major field mission per year is supported by this task.

W92-70553 **465-67-00**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
TOPSAT FEASIBILITY STUDIES
H. A. Zebker 818-354-8780

We propose here to implement feasibility studies which will lead to the Earth-orbiting global topographic mapping mission (TOPSAT). We have been developing a mission concept consisting of a 35 GHz radar interferometer capable of mapping the surface of the Earth at a height accuracy of 2 m or less at a spatial accuracy of 30 m. In addition, this concept is an imaging sensor, that is a radar picture of the surface is developed at the same time as the topographic map. These data thus greatly aid interpretation of the altitude data, as the orbit may be located precisely by imaging known ground features, and additional properties about the surface may be extracted by conventional radar interpretation techniques. These two aspects are extremely important in the use of the TOPSAT data base for disaster management applications. TOPSAT is envisioned as a candidate Earth probe class mission, that is its cost to NASA exclusive of launch is between 100 million and 200 million dollars. It is the purpose of this RTOP to conduct studies which: (1) validate the science scope of the mission, through support of the Topographic Mission Definition Working Group and additional science activities; (2) refine the system design so that reliable performance estimates may be compared with science goals; (3) survey the existing technologies required and determine the degree of technological development needed; and (4) implement a cost analysis to determine realistic mission costs. One major area of uncertainty here is the spacecraft issue. We prefer a low-cost approach, and believe that it may be possible to utilize the GSFC EES basic spacecraft and augment it with additional sensors for attitude estimation, GPS satellite receivers, and an enhanced data system and still remain relatively inexpensive. This study will determine if that approach is reasonable. At present TOPSAT is a joint mission concept with the Italian Space Agency (ASI) and NASA. This collaboration, in addition to saving costs, brings all the benefits of an international collaborative mission to NASA, and thus is beneficial in an institutional sense. Our approach is to implement all the tasks above with ASI, and to divide the final mission implementation plan between the two agencies on the basis of our relative strengths.

W92-70554 **465-67-03**
Goddard Space Flight Center, Greenbelt, MD.
TOPOGRAPHIC PROFILE ANALYSIS
James B. Garvin 301-286-6565

This project will quantitatively analyze high-resolution topographic profiles obtained from aircraft laser altimetry, in order to explore and define fundamental wavelengths associated with dynamic surface processes such as volcanism and coastal erosion. Heretofore unavailable topographic data will be acquired, processed, and interpreted by means of a GSFC aircraft laser altimeter (1 to 10 m footprints, approximately 0.5 m vertical precision) and will, for the first time, permit exploration of the spectral topographic (and slope) properties of coastal erosion and active volcanism. Data has or will be obtained from the GSFC aircraft laser altimeter for selected targets including youthful volcanics (CIMA/Monomay at Cape Cod). High resolution (spatial and vertical) topographic profiles will subsequently be analyzed by means of classical spectral analysis and interpreted. Dominant wavelengths associated with specific terrains and processes will thus be defined; such data can then be used as boundary conditions in mechanical models for certain landforms. Major FY-90 activities included studies of Cape Cod coastal erosion by means of establishing a database of transverse beach profiles, and the

support of the GRSFE Project. Major FY-91 activities will include a geodetic laser survey of Mt. St. Helens and analysis of GRSFE data collected in FY-90. FY-92 effects will include repeat surveys of Monomay Island (Cape Cod) to quantify beach erosion.

W92-70555 **465-67-04**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
AIRBORNE INTERFEROMETRIC TOPOGRAPHY
H. A. Zebker 818-354-8780
(462-74-01)

The objective of this study is to develop an instrument capable of mapping the topography of the Earth's surface at high spatial and vertical resolution, using the technique of radar interferometry to produce a data set which is useful in a variety of Earth science investigations. Our specific objective here is to implement such an instrument on an aircraft system in order to prove the technology in an operational environment, begin to acquire and distribute a data set over a variety of terrain types which will be available to the science community, and develop algorithms and procedures applicable to future spaceborne missions such as TOPSAT. Our approach, consisting of an instrument we call TOPSAR, is to implement a cross track interferometer capability on the existing NASA DC-8 radar for precision topographic mapping. This approach is of minimum cost as it utilizes the existing C-band multichannel radar hardware as much as possible. The major changes required to the existing system are procurement of two new radar antennas, fairings for mounting them on the DC-8, and changes to the radar rf switching network. Eventually, a new radar processor which produces low phase noise images will be needed. Our goal is to produce approximately 2 m height accuracy DEMs with precisely co-registered L and P band polarimeter radar images. This capability follows from operating the L and P band systems simultaneously with the interferometer, and processing the raw data in an integrated manner. This will result in geometrically rectified and cartographically accurate polarimeter data. The three year approach is to (1) develop a new set of interferometric radar antennas, integrate them with the DC-8, and verify the installation with test flights in the U.S. and Italy; (2) develop a phase-accurate processor with aircraft motion compensation algorithms, and produce a sample 2 m map; and (3) integrate the system with the DC-8 P and L band radars in an operational manner. In addition, we will, during the course of this study, acquire data over a variety of sites of differing Earth science applications to support the science community at large and familiarize them with the generation and use of digital topographic data.

W92-70556 **465-68-00**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
AIRBORNE SYNTHETIC APERTURE RADAR (AIRSAR) OPERATIONS
J. J. VanZyl 818-354-1365

The purpose of this plan is to provide the NASA remote sensing program with an Airborne Synthetic Aperture Radar (AIRSAR) system for purposes of testing and evaluating radar techniques in parameterizing surface physical characteristics. In addition, this work serves to develop engineering methods that can be and are used to fabricate spacecraft SAR systems. AIRSAR is a three-frequency (P-, L- and C-band), fully polarimetric SAR that acquires all twelve data channels simultaneously, resulting in co-registered images at all frequencies. In FY-92, the AIRSAR will be maintained and operated during flight missions as prescribed by NASA. The data will be converted to imagery and disseminated to the users in accordance with procedures established by NASA and JPL. Flight hours for engineering testing will be used to assure the proper performance of the SAR and to test new concepts planned for future spacecraft SARs. The plan is to reduce the data from up to 600 scenes to three frequency imagery, each with four polarizations (12 images). System evaluation will be carried out to assess the validity of the data. We shall calibrate the AIRSAR data using the results from calibration flights over Rosamond Dry Lake in California. The development of an upgraded ground data processing facility will be completed; the new system will allow improvements to be made in data quality and increase the processing throughput.

W92-70557 **465-69-00**
Ames Research Center, Moffett Field, CA.
AIRBORNE SCIENCE MANAGEMENT OPERATING WORKING GROUP SUPPORT
J. G. Lawless 415-604-5900
(462-79-00)

The objective of this work is to provide general support to NASA's Airborne Science Management Operation Working Group. Support will be provided for planning activities related to Surface Remote Sensing Program usage of NASA's science applications aircraft. Staff support is also necessary for regular meetings of the Aircraft Science Management Operations Working Group.

W92-70558 **465-75-00**
John C. Stennis Space Center, Bay Saint Louis, MS.
CALIBRATION STUDY
G. R. Meeks 601-688-1935

The Thermal Infrared Multispectral Scanner (TIMS) is an airborne instrument that measures terrestrial thermal infrared radiance in six spectral bands. TIMS is widely used for the detection of spectral emissivity variations and estimation of kinetic temperatures of data targets. Accurate and efficient calibration of the system is required to provide information necessary to derive radiometric quantities from the imagery data. New technologies and engineering techniques are utilized for accomplishing this task. An evaluation and analysis of the calibrated results was undertaken. This temporal analysis was undertaken for the radiometric, spectral and spatial calibration processes. The effect of the capabilities of modern calibration equipment was investigated. An assessment of their contribution to the overall TIMS system performance is underway. Also, the development of an automated calibration workstation was initiated. A configuration for the automation was proposed. The TIMS user community has revealed a major problem with the temperature variation of the blackbodies during data collection missions. This problem makes the task of calculating surface temperature difficult. A study will be conducted to determine the cause of the problem and possible solutions. This will include data collection missions and data comparisons from previous missions. The results will include a characterization of the problem and a recommended solution. This proposal will continue the efforts of improving the calibration capabilities for the TIMS. Analytical techniques will be developed to ensure the consistency of the calibration data. Various methods shall be outlined to detect anomalies, if they occur. This study also aims to automate the entire process of calibrating the TIMS. This allows for verification of the validity of the calibration, efficiency in performing the calibration, and improvement in accuracy of the data. It is proposed that each of the instruments used for calibration be connected to a central computer, which then controls the various tasks of calibrating the TIMS. The automation effort utilizes existing equipment.

W92-70559 **465-96-00**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
SOLID EARTH SCIENCE BRANCH PROGRAM SUPPORT
D. J. McCleese 818-354-2317

The objective of this RTOP is to provide support to the NASA Solid Earth Sciences Branch in the study, evaluation, definition, and development of remote sensing techniques to study land processes phenomena as they shape our biologic and geologic environment. The approach will consist of two elements: (1) invite distinguished visiting scientists in the field to spend some time (a few weeks to a few months) at JPL to work with JPL scientists; and (2) support new ideas and approaches to the level of allowing the submission of viable proposals for peer review.

W92-70560 **465-97-00**
Goddard Space Flight Center, Greenbelt, MD.
SOLID EARTH SCIENCE PROGRAM SUPPORT
David E. Smith 301-286-8671

This RTOP provides programmatic support to the NASA Headquarters Solid Earth Sciences Program Office and to the Laboratory for Terrestrial Physics at GSFC.

W92-70561 **465-97-00**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
DOSE PROGRAM MANAGEMENT
W. G. Melbourne 818-354-5071

The purpose of this RTOP is to provide a framework for the management of activity at JPL in the NASA program on the Dynamics of the Solid Earth (DOSE). This RTOP consists of two tasks corresponding to the DOSE Program Scientist and the DOSE Program Technologist. Ultimate responsibility for all aspects of the program at JPL rests with the JPL Geodynamics Program Manager. The Geodynamics Program Manager is assisted and advised by the DOSE Program Scientist on scientific issues and by the DOSE Program Technologist on technology issues. The Program Manager delegates responsibility to guide and monitor science research and technology development to the DOSE Program Scientist and DOSE Program Technologist, respectively.

Climate and Hydrologic Systems Modeling and Data Analysis

W92-70562 **578-10-00**
Marshall Space Flight Center, Huntsville, AL.
MODELING AND DATA ANALYSIS, PHYSICAL CLIMATE AND HYDROLOGICAL SYSTEMS, DATA ANALYSIS
R. J. Koczor 205-544-3078

The objective is to contribute to the NASA Global Scale Processes Research Program objectives by performing diagnostic and theoretical studies of global-scale atmospheric systems to: (1) develop new and improved spaceborne atmospheric sensing techniques; (2) develop new techniques to extract information from and more fully utilize existing and planned spaceborne atmospheric sensing systems; and (3) contribute to the development of our understanding of global scale atmospheric processes. The approaches are to: conduct detailed analyses with space and ground-based data sets, guided by theoretical studies, to understand the role of latent heat release in the dynamics of cyclones; examine global atmospheric processes to gain improved understanding of the scales of motion; develop techniques for including satellite data in diagnostic procedures; and develop strategies and mission concepts to measure global scale processes from space platforms.

W92-70563 **578-10-00**
Langley Research Center, Hampton, VA.
CLIMATE AND HYDROLOGIC SYSTEMS MODELING AND DATA ANALYSIS
Edwin F. Harrison 804-864-5663

The objective is to conduct global studies of atmospheric and surface radiation budget. The following approach will be used: (1) continue utilizing ISCCP data to produce global surface radiation results with spatial and temporal characteristics and accuracy which satisfy the requirements of the World Climate Research Program; (2) validate satellite-derived surface radiation flux estimates with surface measurements; (3) investigate statistical relationships between radiation and meteorological quantities such as water vapor and clouds; and (4) develop, evaluate, and apply techniques for retrieval of radiation flux divergence within the atmosphere and use results with surface flux divergence data to study climate processes.

W92-70564 **578-11-00**
Goddard Space Flight Center, Greenbelt, MD.
OBSERVATIONS AND MODELING OF AIR-LAND SURFACE INTERACTIONS
Franco Einaudi 301-286-6786

The purpose of this task is twofold. The first purpose is to employ numerical modeling to examine the role of land surface characteristics on atmospheric processes. Two processes are the subject of specific focus: on the short time scale the formation of boundary layer cloudiness in response to vegetation and soil moisture, and on the longer time scale, the effect of surface characteristics on the possible exacerbation of the 1988 midwestern drought. The second purpose is to experiment with methods of incorporating new remotely sensed information into numerical models. This includes finding ways to combine microwave SSMI data, AVHRR data, and/or the products of VIS/IR rain estimation techniques to improve upon current retrievals of soil moisture and key vegetation properties.

W92-70565 **578-11-00**
Goddard Space Flight Center, Greenbelt, MD.
CLIMATE AND HYDROLOGIC SYSTEMS MODELING AND DATA ANALYSIS
Albert Arking 301-286-7208

The objectives are to: (1) improve understanding of the effect of ice-content in cirrus and stratus and their relationship with large scale meteorological variables; (2) enhance understanding of cloud processes through theoretical and observational studies; and (3) investigate the variability of temperature and moisture profiles in convective regimes. The approaches are to: (1) formulate the parameterization for the ice content of cirriform and stratiform clouds in GCM; (2) improve existing retrieval techniques for marine stratiform clouds; (3) utilize GCM and satellite data to study spatial and temporal variability of cloud and radiative effects; and (4) develop improved convective parameterization to minimize the rejection of moisture data assimilated into forecast models.

W92-70566 **578-11-01**
Ames Research Center, Moffett Field, CA.
CLIMATE MODELING WITH EMPHASIS ON AEROSOLS AND CLOUDS
J. B. Pollack 415-604-5530
(460-43-47; 460-42-10)

The objectives of this RTOP are the following: a coordinated set of theoretical, laboratory, and field investigations of the chemical and radiative properties of clouds and natural (e.g., volcanic) and man-made atmospheric aerosol particles is conducted in order to assess their impact on regional and global climate. The field investigations are intended to provide complementary information on clouds and aerosols to that being obtained from spacecraft platforms (e.g., SAM, SAGE II and SME) so as to insure that a comprehensive set of properties is gathered for climatic analyses. The theoretical and laboratory tasks are directed at interpreting and utilizing the data sets to perform the desired climatic assessments. The approaches of the RTOP are as follows: the centerpiece of the field investigations is a set of coordinated experiments which are flown together on appropriate aircraft platforms. Both theoretical modeling and laboratory studies are used to define the mechanisms of aerosol and cloud formation to provide hypotheses that can be tested by the field investigations and to ultimately provide predictive tools. Theoretical investigations involving radiative transfer, dynamics, and particle formation are utilized for making the climatic assessments, including simulations with a three-dimensional climate model.

W92-70567 **578-11-02**
Goddard Inst. for Space Studies, New York, NY.
EXTENSION AND TESTING OF THE HYDROLOGIC PARAMETERIZATION IN THE GISS ATMOSPHERE GCM
Peter Eagleson 212-678-5588

The overall objective of this work is to test and improve the capability of the GISS general circulation model to reproduce critical aspects of global hydroclimatology, via the development of new

diagnostic methods for evaluating the cycling of moisture in the model and the implementation of subgrid-scale fluctuations in the model's ground hydrology parameterization. The approaches are: (1) development of a global one-dimensional analog of the GISS GCM that captures the essential radiative and convective processes of a global climate; (2) comparison of various aspects of proposed GCM ground hydrology improvements in the one-dimensional model; and (3) implementation of a new ground hydrology model in the GCM based on the results of the 1-D screening tests.

W92-70568 **578-12-00**
Goddard Space Flight Center, Greenbelt, MD.
INTERACTIVE IMAGE DATA ANALYSIS AND GEMPAK USER SUPPORT
Franco Einaudi 301-286-6786

The objectives are to: (1) develop an interactive image spreadsheet which can be used to analyze multichannel satellite images over an image workstation; (2) maintain and expand the GEMPAK (General Meteorological Package) software and associated graphics software; and (3) design, develop, test, and deploy a data capture and distribution facility for the GMS satellite and similarly for INSAT. The approaches are to: (1) obtain super image workstation and software, design and implement interactive image spreadsheet prototypes; (2) maintain GEMPAK software and documentation, extend the analysis functions, upgrade diagnostic package, and improve real-time data ingest; and (3) install the GMS system and begin negotiations for the INSAT.

W92-70569 **578-12-01**
Goddard Inst. for Space Studies, New York, NY.
EXPERIMENTAL CLOUD ANALYSIS TECHNIQUES
William B. Rossow 212-678-5567

The objectives are to: (1) develop new multi-channel, multi-instrument cloud analysis algorithms, including new cloud detection schemes and more sophisticated radiative transfer models; and (2) develop analysis methods to infer cloud-radiative feedbacks from the ISCCP data. The approaches are to: (1) examine ISCCP results by comparison to observations from a full complement of instruments on the NOAA polar orbiters, including IR and microwave sounders; (2) test new multi-spectral algorithms and radiative analysis models by comparisons to FIRE observations of cirrus and marine stratus clouds; (3) develop methodologies to infer cloud-radiative feedbacks from ISCCP data; compare results to products produced by ERBE and the Surface Radiation Budget Project; and (4) compare cloud and radiation budgets to climate model simulations.

W92-70570 **578-12-02**
Goddard Inst. for Space Studies, New York, NY.
AN INTEGRATED STUDY OF SURFACE PROPERTY VARIATIONS
William B. Rossow 212-678-5567
(148-90-00)

The objective is to develop a combined analysis procedure, using both satellite and surface observations, to obtain accurate estimates of global surface albedo and temperatures. Data from ISCCP will be refined by including the effects of surface spectral and angular dependence in the analysis models and by extending the calibration monitoring of AVHRR to the remaining spectral channels. By combining the ISCCP surface visible reflectances and brightness temperatures with other measurements at other wavelengths and from conventional surface measurements, we will determine surface albedo and temperature over the whole globe for a normal year and a perturbed year.

W92-70571 **578-12-03**
Goddard Space Flight Center, Greenbelt, MD.
CLIMATE AND HYDROLOGIC SYSTEMS MODELING AND DATA ANALYSIS
Albert Arking 301-286-7208

The objectives are to: (1) improve understanding of shortwave component of the earth radiation budget; and (2) determine the effect of cloud radiative forcing on climate at the earth surface. The approaches are to: (1) implement and validate solar model with ISCCP B3,C1 and B3 AVHRR data; and (2) utilize GCM and satellite observations to derived earth radiative budget based on idealized GCM experiments.

W92-70572 **578-12-10**
Goddard Space Flight Center, Greenbelt, MD.
ENERGY AND HYDROLOGY DATA ANALYSIS
J. R. Bates 301-286-7482

This study is designed to provide global data sets from observed heating and hydrological processes in the atmosphere. This year, data was processed from October 1979 through January 1981. Next year, the new GLA interactive system will process data from 1979 to 1983.

W92-70573 **578-12-18**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
VARIABILITY OF HYDROLOGIC BALANCE OVER GLOBAL OCEANS
W. T. Liu 818-354-2394
(578-12-19; 148-90-27)

This is a study in response to NASA NRA-88-OSSA-11, IDP 88-017, on the role of the hydrologic cycle in atmospheric-ocean interaction. It is centered on the observations of the Special Sensor Microwave Imager (SSMI) on the operational spacecraft of the Defense Meteorological Space Program. Monthly evaporation over global oceans will be computed using the sea surface temperature derived from operational infrared radiometers and the wind speed and water vapor derived from SSMI. Each parameter from spaceborne sensors will be evaluated with available in situ measurements and compared with products from atmospheric general circulation models. The wind speed from SSMI will be assimilated into the atmospheric general circulation model (AGCM) at Goddard Space Flight Center (GSFC). The divergence of moisture transport over global oceans derived from analysis fields of AGCM will be examined. Methods to derive the divergence term from satellite observations will be explored. Rainfall derived from satellite data and by the budget method will be used in an attempt to close the atmospheric water balance. In addition to studying the temporal (from a month to several years) and spatial (from 100 km to basin-wide) variabilities of the various terms in the hydrological balance over the global oceans, we will focus on a few regional studies in the tropical Pacific. The relative roles of surface evaporation and surface moisture convergence in changing organized convection and precipitation over the tropical Pacific will be examined.

W92-70574 **578-12-19**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
REMOTE SENSING OF AIR-SEA FLUXES
W. T. Liu 818-354-2394
(578-12-18)

The objectives are to study, using spaceborne sensors, the interactive processes of ocean-atmosphere exchanges in momentum, heat, and moisture and their effects on ocean thermodynamics and dynamics. Feasibility studies on computing latent heat flux using Seasat/Scanning Multichannel Microwave Radiometer (SMMR) data were successfully performed. A global relation between precipitable water and surface humidity was derived. Adaptation of bulk parameterization models to satellite data in the tropical oceans was examined. Four years of Nimbus/SMMR data were evaluated and the latent heat fluxes computed in the tropical Pacific; the seasonal cycles and the anomalies during the 1982 to 1983 El Nino Southern Oscillation (ENSO) episode were studied. Combining with surface insolation, the net heat flux fields were constructed as part of the Tropical Ocean Global Atmosphere (TOGA) Heat Exchange Project. The results were used to study thermal forcing of the sea surface temperature changes in the eastern tropical Pacific. In light of our results, the conventional approximations used in computing latent heat flux in ocean numerical models were evaluated. High frequency variability of humidity distribution in the atmosphere is being studied to improve the temporal resolution of our technique. Wind forcing

of deep current during the OCEAN STORM experiment is being studied. Combined wind and thermal forcings expressed as the Monin-Obulkov depth will be compared with ocean isothermal mixed layer depth. The effect of hydrologic forcing (precipitation-evaporation) on the isopycnal mixed layer depth in the tropical ocean will be examined. Extension of our heat flux technique to use Special Sensor Microwave Imager (SSMI), Advanced Very High Resolution Radiometer (AVHRR) and International Satellite Cloud Climatology Project (ISCCP) data on global tropical ocean will be pursued.

W92-70575 **578-12-20**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
METEOROLOGICAL PARAMETERS EXTRACTION
M. T. Chahine 818-354-6057
(578-12-21)

The overall objective of the proposed research is the development of accurate numerical analysis methods to retrieve, from satellite data, important meteorological parameters needed for weather and climate studies. To accomplish this we plan to: conduct theoretical and applied studies for the continued improvement of numerical techniques to retrieve atmospheric and surface parameters from radiance data measured by the NOAA HIRS/MSU sounders; apply the retrieval methods to produce a ten year data set (1979 to 1989) from the High Resolution Infrared Sounder/Microwave Sounding Unit (HIRS/MSU) of several meteorological parameters such as clear-column vertical temperature and humidity profiles, sea-surface temperature, and the distribution of cloud heights and amounts; verify the accuracy of the results by participation in national and international workshops dedicated to this objective, also by comparison with co-located radiosonde and sea-surface data and with cloud nephanalysis obtained independently from other sources; and apply the results to observe and study various air-surface interaction processes on monthly to seasonal timescales. Simultaneous determination of the atmospheric and surface thermal structure and the cloud distribution provides information on heat sources and sinks, storage rates and transport phenomena in the atmosphere. Such information is critical in determining the driving mechanisms for motions in the atmosphere and oceans and in improving numerical weather prediction.

W92-70576 **578-12-21**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
ATMOSPHERIC PARAMETER MAPPING
K. J. Hussey 818-354-4016
(578-12-20)

The primary objective is to continue development of the Scientific Data Visualization capability to produce very high quality color maps and time-lapse imagery of global atmospheric parameters derived from NOAA HIRS2/MSU and other satellite data. Other objectives include: increasing the cost effectiveness of map/time-series production, making the process of climatic map/time-series generation and data analysis more readily available to atmospheric scientists, and to provide continuing support to M. Chahine and others, in the development of new parameter maps/time-series derived from the combination and integration of existing atmospheric data fields. The approach to continue research and production of high quality time series images and global atmospheric parameter maps in a cost effective manner is as follows. The Digital Image Animation Laboratory (DIAL) will be upgraded to increase productivity and maintain compatibility with the Jet Propulsion Laboratory (JPL) Multimission Image Processing Laboratory (MIPL). The VICAR image processing and visualization software will be expanded on the Solbourne multiprocessor workstations as new software is developed and discovered. Time-series analysis software will be improved and optimized. Three-dimensional analysis and display software will be upgraded and ported into a Unix X-windows environment. The functionality of a public domain or commercially available visualization software package will be integrated into the Automated Raster Cartography System (ARCS). The combination of computer graphics and image processing techniques will be continued as a means of improving the quality of graphic overlays in time-series imagery. Animations showing global changes over the entire year (1979) will be produced along with a high-resolution animation of Hurricane Gilbert, under the direction of M. Chahine and J. Susskind. Steps will be taken to couple data visualization with data validation and to make our tools compatible with other investigators.

W92-70577 **578-21-00**
Goddard Space Flight Center, Greenbelt, MD.
PHYSICAL OCEANOGRAPHY
Michele M. Rienecker 301-286-6178
(578-22-00)

Continuing tasks within this RTOP include: 578-21-01 by Adamec to model and investigate mid-latitude mesoscale variability in the northern Atlantic and Southern Pacific Oceans; 578-21-02 by Atlas to assimilate wind measurements to produce high resolution gridded forcing for ocean applications; 578-21-03 by Busalacchi to study the upper-ocean response to surface fluxes of momentum and heat in the tropics; and 578-21-05 by Rienecker to use dynamical models and data assimilation techniques to study the dynamics and thermodynamics of the North Pacific circulation.

W92-70578 **578-21-12**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
TROPICAL OCEAN CIRCULATION FROM ALTIMETRY AND NUMERICAL MODELING
C. M. Perigaud 818-354-8203

The long term objective of this RTOP is to investigate the utility of satellite altimetry for studying the tropical oceanic circulation and its variations. The current focus is Geosat altimeter data. The edited, geographically gridded Geosat data set is used for observations of sea level variations. The latter are simulated using different theoretical approaches (reduced-gravity model of the Indian Ocean, Geophysical Fluid Dynamics Laboratory (GFDL) Ocean General Circulation Model over the tropical Pacific). Optimal estimation techniques (Kalman filtering and smoothing or adjoint models) are the main tools for analyzing the data in a dynamical given context. Both descriptive and modeling studies are conducted. The objectives are: (1) comparison of Geosat observations with shallow-water model predictions in the Indian Ocean. The objectives are both large scale variations (seasonal and interannual) and mesoscale variations (Somali current, Bay of the Bengal, 20 to 60 day waves); (2) comparison of Geosat observations with OGCM model predictions in the Pacific Ocean. The objective is both large scale variations (seasonal and interannual) and mesoscale (instability waves along the shear front of the North Equatorial Counter Current); (3) investigation of methods for fitting ocean models to altimeter data. The initial focus is linear equatorial waves in the Pacific or Indian Oceans.

W92-70579 **578-21-13**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
OCEAN MODELING AND DATA ASSIMILATION
D. Halpern 818-354-5327

Routine predictions of interannual climate variation will eventually combine extensive satellite data sets with advanced coupled ocean-atmosphere models. That an increase in forecast skill of El Nino and La Nina episodes will be accompanied with improved models and improved data assimilation schemes is a tenet of the Tropical Ocean Global Atmosphere (TOGA) program. Sequential updating of a model with remote sensing data is a natural way to extract information from imperfectly known dynamics and incomplete observations. Only satellites provide frequent global coverage; however, the coverage is only at a single level, namely the sea surface. It is a belief among oceanographers that an ocean general circulation model (OGCM) can extrapolate satellite surface information, such as sea surface height, throughout the ocean interior. This RTOP addresses the question: to what extent does assimilation of satellite sea surface height information improve the initialization of tropical OGCMs, and in turn improve the seasonal description of heat and momentum transports of

equatorial currents? The tropical Pacific OGCM developed at NOAA's Geophysical Fluid Dynamics Laboratory (GFDL) has been transferred to the CRAY-2 at NASA Ames. Analyses of OGCM-simulated tropical Pacific current variations during the 1987 and 1988 period will be emphasized. El Nino and La Nina episodes and GEOSAT measurements all occurred during this period.

W92-70580 **578-22-00**
Goddard Space Flight Center, Greenbelt, MD.
PHYSICAL OCEANOGRAPHY
Michele M. Rienecker 301-286-6178
(578-21-00)

Continuing tasks within this RTOP include: 578-22-01 by Marsh and Koblinsky to provide improved and geodetically consistent orbits, geoids and sea surface topography models for satellite altimeter observations used in oceanographic applications; and 578-22-02 by Koblinsky and Marsh to use satellite altimetry to map the large scale ocean circulation. Included with this RTOP are the funding requests 578-22-04 for mainframe computing at the NASA Center for Computational Sciences for RTOP-related research; and 578-22-05 for program support in the Oceans and Ice Branch.

W92-70581 **578-22-22**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
THEORETICAL/NUMERICAL STUDY OF THE DYNAMICS OF OCEAN WAVES
M. H. Freilich 818-354-4658

This work has two objectives: (1) to develop dynamically based models of wave-induced nearshore water motions, as one component of a larger collaborative effort Shoaling Region and Surf Zone Nonlinear Wave Models between Freilich (JPL), Guza (SIO) and Elgar (WSU) (the overall project has been accepted and funded by NSF through 6/93 (most recent proposal accepted at 12/89 panel meeting)); (2) to develop techniques for performing global validation and uniformly accurate refinement of scatterometer and altimeter wind model functions, using surface analyses from operational weather prediction models (with R. Scott Dunbar). The approach for the nearshore waves work is to develop and test, using field and laboratory data, dynamical models incorporating nonlinear wave-wave interactions for the description of wave transformations both before and after breaking. The 1-D near-resonant model of Freilich and Guza (1984) has been extended to accommodate a full spectrum of directional waves - the resulting 2-D model for nonbreaking waves has no adjustable parameters. Analysis of 2-D model results has demonstrated the need to develop techniques for comparing quantitatively directional spectrum estimates obtained from different arrays and having different statistical properties. The approach for the model function requirement work is to use surface analyses from operational numerical weather prediction models to provide a global, extensive data set with which to test and refine scatterometer and altimeter model functions. NWP model analyses are interpolated in both space and time to the positions of satellite backscatter cross-section measurements. The sigma-o/wind pairs are stratified based on wind speed/direction, geographical location, SST, stability, etc. In addition, the use of multiple NWP models allows weighting the model values based on expected accuracy of the NWP analyses. Most importantly, the technique allows calculation of 'model function uncertainty' as a function of wind velocity and radar parameters. The primary upcoming objective is to utilize the technique to refine the ERS-1 C-band scatterometer model function.

W92-70582 **578-22-23**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
VARIATIONS OF GLOBAL SST
D. Halpern 818-354-5327
(148-90-00)

Sea surface temperature (SST) is an important boundary condition of atmospheric circulation. The long-term trend of the global surface air temperature and SST distributions during the past century is about 0.5 C per 100 years. Substantial variations occur between different SST data sets. Over large geographical regions, SST differences of 1 to 2 C were found between the data sets derived from High Resolution Infrared Sounder (HIRS2) and Microwave Sounding Unit (MSU) (HIRS2/MSU data set) and from ship measurements called Comprehensive Ocean-Atmosphere Data Set (COADS). This research will determine the sensitivity of simulations performed with the University of California/Los Angeles (UCLA) atmospheric general circulation model (AGCM) to global SST distributions compiled monthly from HIRS2/MSU satellite measurements, which have very little aliasing, and from COADS ship measurements. The multi-decadal COADS SST data set is frequently used as a surrogate of global SST, even though the large amount of aliasing caused by inadequate sampling is well known. If the simulated atmospheric circulations are statistically equivalent, then the reliability of the COADS SST data set for climate studies is enhanced. The UCLA AGCM simulations with COADS and HIRS2/MSU SST data sets prescribed as boundary conditions are being compared with a control run involving only SST climatology. Numerical simulations using the HIRS2/MSU for perpetual January and July 1979 conditions have been completed. Simulations with the COADS data set have recently begun.

W92-70583 **578-22-24**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
OCEAN CIRCULATION FROM SATELLITE ALTIMETRY
L.-L. Fu 818-354-8167

The long term objectives of this study are: to investigate the utility of satellite altimetry as a tool for studying the circulation of the global oceans, and to explore ways to combine altimetry observations with ocean models to achieve an optimal description of ocean circulation and its variabilities. The current focus is Geosat altimeter data. After the launch of the ERS-1 satellite, we will extend our studies to that data set. We have established a data processing facility to produce an edited, geographically gridded Geosat data set for efficient scientific use of the data. For the ERS-1 altimeter, which will not be in a tight repeat orbit, we will develop software to compute the crossover differences for ocean variability studies. Optimal estimation techniques (objective mapping, Kalman filtering and smoothing) are the main tools for analyzing the data for studying ocean dynamics. We will conduct both descriptive and modelling studies. Following are the near-term objectives: (1) Improvement of Geosat Data. We will implement the wet tropospheric correction from a combination of SSMI and SMMR climatology to the gridded Geosat data. The once-per-revolution orbit error will be estimated and made available to the data users; (2) Gyre-Scale Variability. The refined Geosat data will be mapped to a global 5 degree x 5 degree grid for the study of gyre-scale variabilities. The correlation of the variability to wind stress, sea-state, and atmospheric pressure will be studied; (3) Modelling/Data Assimilation. We will continue the Kalman filter analysis of the Geosat data in the Tropical Pacific Ocean and submit a manuscript on the result for publication; (4) ERS-1 Altimetry Analysis. We will develop software to construct sea-level time series from crossover differences of the ERS-1 altimeter data; and (5) Support NASA in the development and use of remote sensing techniques to study physical oceanic processes and their interactions with the atmosphere.

W92-70584 **578-22-25**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
STUDIES OF SEA SURFACE TOPOGRAPHY AND TEMPERATURE
V. Zlotnicki 818-354-5519
(578-22-27)

The goal of this work is to measure, understand, and help predict the circulation of the oceans at mesoscales and longer. Satellite altimetry, infrared and microwave data combined with in-situ data, and data assimilation into a hierarchy of numerical models are the areas of emphasis. The main objectives for the coming year are: (1) to assess and optimize orbit and environmental corrections to ERS-1 data by minimizing their discrepancy from tide gage data; (2) to combine ERS-1 altimeter crossover data with our existing Geosat ERM database, and ascertain whether

interannual ocean changes can be distinguished from differences in the measuring systems; (3) to release for general use our working Geosat data set with GEMT2 orbit, SSMI water vapor, and suggested once/rev residual orbit correction; (4) to assimilate Geosat altimeter data into a quasi-geostrophic model of the Agulhas current, and evaluate assimilation techniques. The approaches are to compute crossover differences, then adjust models of the residual errors to minimize both the crossover differences and the overall discrepancy of the altimeter heights to tide gage data; use repeat hydrographic data in our ongoing collaboration with the U. of Kiel, assess interannual changes in the quiet Azores region; and extend the nudging technique (e.g., Holland and Rizzoli, 1989) with weighting coefficients which are slightly degraded versions of optimal least squares coefficients.

W92-70585 **578-22-26**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
SURFACE WIND DISTRIBUTION OVER THE OCEAN
D. Halpern 818-354-5327
(578-22-26; 578-22-00)

Surface wind motion over the ocean is the primary forcing mechanism of ocean-atmosphere interaction on seasonal-to-interannual time scales. The surface wind field is time dependent with prominent scales of motion ranging from minutes to years and is space dependent with spatial variations of tens to thousands of kilometers. Because of numerous difficulties associated with making long-term closely-spaced wind measurements over the ocean with in situ instrumentation, the oceanic surface wind field is extremely undersampled. That the space-time structure of the surface wind field is poorly known is considered to be a severe limitation on understanding dynamics of oceanic flow and thermal variations and of oceanic biogeochemical cycles. Satellite-borne wind-measuring instrumentation will provide extensive data sets of the global surface wind field throughout the 1990s. Research towards understanding the behavior of the surface wind field over the ocean is described in the RTOP. Three fundamental questions are addressed. (1) Are spatial and temporal scales of surface wind motion significantly different between the three equatorial oceans? (2) How well do global distributions of surface wind over the ocean estimated from satellite measurements compare with surface wind data products computed from a numerical model forecast-analysis system? (3) What is the vertical distribution of the wind vector within the equatorial planetary boundary layer? The following types of data will be analyzed: ERS-1 and Seasat scatterometer measurements of surface wind components (ERS-1 is scheduled for launch in May 1991); Special Sensor Microwave Imager (SSMI) microwave radiometer measurements of surface wind speed; European Center for Medium Weather Forecasts (ECMWF) surface wind components; rawinsonde observations and low-level cloud motion vectors at Fanning Island; Tropical Ocean Global Atmosphere (TOGA) and World Ocean Circulation Experiment (WOCE) moored buoy wind measurements recorded at worldwide sites. Result will aid in the design of a global ocean observing system , specifically in the sampling strategies for the NASA Scatterometer (NSCAT) and STIKSCAT. Also, results will contribute to heat budget studies, wind-forced ocean circulations, determination of critical areas for deployment of moored wind-measuring systems, detection of interannual variation of wind speed over the global ocean, validation of satellite surface wind data sets, and the influence of wind motions with 40- to 50-day periods on the onset and maintenance of El Nino.

W92-70586 **578-22-26**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
AN ATLAS OF GLOBAL MONTHLY MEAN OCEANOGRAPHIC VARIABLES
D. Halpern 818-354-5327
(578-21-13; 578-22-26; 578-22-00)

The unique perspective from space provides observations well suited for the global ocean, which is an essential component of the climatic system. Now, in the early stages of creating long time series, it is timely to develop methods for presenting global multi-variable distributions. Halpern et al. (1991) published an atlas of monthly mean distributions of satellite measurements of surface wind speed, sea surface temperature, and sea surface height variation from January to December 1988. The year 1988 was chosen because it is the first occasion when an annual cycle of simultaneous satellite observations of these variables was recorded. The following monthly mean global distributions for 1988 were presented with a common color scale and geographical map: sea surface height variation estimated from GEOSAT; surface wind speed estimated from the Special Sensor Microwave Imager (SSMI) on a Defense Meteorological Satellite Program (DMSP) spacecraft; sea surface temperature estimated from the Advanced Very High Resolution Radiometer (AVHRR/2) on NOAA spacecrafts; and the Cartesian components of the 10-m height wind vector computed by ECMWF. Charts of monthly mean value, sampling distribution, and standard deviation value were displayed. The atlas also contained annual mean distributions. An atlas of monthly mean distributions of oceanographic variables is a living document: no two months are identical. Additional atlases are required for interpretations of global climate variations and to provide internally consistent data sets for climate initialization and validation studies. This RTOP describes publication of annual atlases for 1987 and 1989, each of which will use data processing procedures similar to that employed in the atlas for 1988 data. Not all data sets will appear in each atlas because of limited record-lengths. GEOSAT sea surface height data will only be in the 1987 atlas. Near-surface current components computed from satellite-tracked drifting buoy positions will appear for the first time in the 1989 atlas. We anticipate making additional atlases for data in years 1990 and beyond.

W92-70587 **578-22-26**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
LARGE SCALE AIR-SEA INTERACTIONS
D. Halpern 818-354-5327
(578-22-00; 578-22-13)

Understanding the role of ocean circulation in the dynamics of large-scale, season-to-interannual sea surface temperature and air-sea exchange of carbon dioxide variations, both in equatorial and middle latitudes, is a basic tenet of Climate Variability (CLIVAR), which is WCRP's new global ocean global atmosphere program intended to be the successor to the World Ocean Circulation Experiment (WOCE) and the Tropical Ocean Global Atmosphere (TOGA). During the onset of El Nino, the Equatorial Undercurrent is known to advect warm water eastward in the upper ocean along the equator. In contrast, the role of the eastward flowing North Equatorial Countercurrent (NECC) during the onset and maintenance of El Nino conditions remains to be described. Preliminary evidence from the TOGA sea level network in the western Pacific indicates an increase in NECC transport during El Nino. Whether this feature occurs in the central and eastern Pacific, where, according to Ocean General Circulation Model (OGCM) simulations, the annual cycle of NECC transport is largest, remains to be determined. In flowing eastward against the prevailing westward winds, the NECC represents an ocean circulation phenomenon whose dynamics have long interested oceanographers. The latitudinally varying wind-stress curl produces an upward tilt of the thermocline towards the north and, consequently, a downward slope of sea surface height of about 25 cm over the 5 to 10 deg N NECC. While Sverdrup dynamics readily explain the climatological-mean structure of the NECC, the degree of Sverdrup balance throughout an annual cycle is not known because of the heretofore absence of suitable measurements. Simulations of the climatological-mean Pacific NECC with an ocean general circulation model exhibit large variations in longitude. Satellite altimeter sea surface height data have the potential of monitoring the entire NECC with minimal aliasing in time and space because the NECC is in approximate geostrophic balance. The surface geostrophic current is computed from the east-west and north-south gradients of sea surface topography. A time series of monthly mean estimates of geostrophic (or NECC) transport will be developed from GEOSAT data, and continued in time with ERS-1 and TOPEX/POSEIDON altimeter

data. (Note: The scope of this RTOP has been reduced. Two other RTOPs (578-22-XX-A and 578-22-XX-B) were created because of work originating with this RTOP.)

W92-70588 **578-22-27**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
JPL OCEANOGRAPHY GROUP PLAN FOR A COMMON COMPUTER SYSTEM
V. Zlotnicki 818-354-5519
(578-22-25)

The goals of this task remain as in previous years: to provide a multi-user computer system serving the basic computing and data management needs of the Physical Oceanography and Biological-Polar Oceanography groups at JPL, both now and in their evolving roles in interdisciplinary studies. The computers funded under this RTOP are used to organize, process and analyze large volumes of satellite data and numerical model output. This RTOP assumes that a supercomputer, such as exist at Goddard, JPL, or Ames, are available to run numerical ocean models at no cost to either this RTOP or those of the investigators of the Oceanography groups, as has occurred for the past two years. The computer system is based on a closely networked group of UNIX machines (SUN and lately, Silicon Graphics), VAXes and Macintoshes, and shared peripherals accessible to all members of the group. Some of the machines on the network are shared among all group members on an equal footing; other machines are task-specific, in that they were purchased outside this RTOP, but they are shared in a not-to-interfere basis with other group members, and maintained under this RTOP. Upgrades to this Oceanography Computing Network (OCN) are dictated by the ever-increasing size of the data handled, and the increased sophistication of the analysis, modelling, and assimilation tasks performed. The open architecture, and standards such as UNIX and the SCSI interface allows many economical upgrade paths. Between FY-88 and FY-90 this RTOP included all hardware and software requests for both groups. Following last year's guidance from NASA, this FY-92 request includes only those needs common to many members, such as system managers, software maintenance, upgrades to large shared machines (the Silicon Graphics), networking needs, etc. Hardware and software unique to a particular task are now requested and justified together with that task.

W92-70589 **578-22-28**
Marshall Space Flight Center, Huntsville, AL.
MODELING AND DATA ANALYSIS, CLIMATE AND HYDROLOGIC SYSTEMS
R. J. Koczor 205-544-3078

The objectives of this RTOP are to develop oceanic retrievals of surface wind speed, water vapor and cloud water using special sensor microwave imager data; evaluate these products; and address the usefulness of future space-based platforms. The approach will be to utilize the expertise of university and private contractor groups and Marshall Space Flight Center (MSFC) in-house talents to accomplish these activities.

W92-70590 **578-30-00**
Goddard Space Flight Center, Greenbelt, MD.
POLAR OCEANOGRAPHY
Robert A. Bindschadler 301-286-7611
(148-90-00)

The objective of this RTOP is to perform research on sea ice, ice shelves, and continental ice sheets and related oceanographic and climatological processes and their impact on global change. The activities include: validation of sea ice parameters derived from Defense Meteorological Satellite Program (DMSP) Special Sensor Microwave Imager (SSM/I) and ancillary data with special attention given to the 85.5 GHz channel and its application for detection of thin sea ice; modeling and data analysis to better understand the nature of microwave emissions from snow and ice using a combination of surface, airborne and satellite data; investigations of the physical processes which occur in the Arctic oceans particularly the exchange of heat between the ocean and the atmosphere; derivation and analysis of a time series of sea-ice concentration and ice sheet data seeking regional or hemispheric trends which might portend changes in global climate or indicate the nature of interactions between sea ice and either the ocean or atmosphere; and mapping of the hydrologic zones and topography of the ice sheets with synthetic aperture radar and radar altimeters and seeking to identify areas experiencing major change.

W92-70591 **578-32-22**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
GLOBAL SEA LEVEL CHANGES
R. S. Gross 818-354-4010
(465-14-02; 148-90-00)

The fundamental objectives of this study are: (1) to determine improved estimates for the eustatic changes in sea level; and (2) to estimate secular and other long period changes in polar ice volume. Our approach is of an interdisciplinary nature and will include the analysis of several geodetic, oceanographic, and meteorological sets, together with extensive numerical modeling efforts. The various data types include surface temperature and monthly tide gauge data, Earth's rotation and gravitational field data, space geodetic observations of vertical crustal motion, and satellite altimeter results. Improved estimates for the global rise in sea level will be obtained by analyzing tide gauge data directly, and by observing and subsequently interpreting the effects of a changing sea level on the Earth's rotation and gravitational field. In turn, the Earth's rotation and gravitational field data results, as well as observations of vertical crustal motions, will be used to derive new constraints in the post-glacial rebound modeling effort. Better estimates of the amount of melting of the Antarctic and Greenland ice caps, and of the continental glaciers will be computed by recovering and then by interpreting the expected effect of this melting upon the Earth's rotation and gravitational field. Tide gauge data will be used to directly estimate the global change in the level of the seas. Data obtained from space-geodetic observations of the Earth's rotation and gravitational field will be used to indirectly estimate the sea level change through its effect of changing the Earth's mass distribution and hence rotation and gravitational field. The space-geodetic data will also be used to derive new constraints for use in the post-glacial rebound modeling effort. A decrease in the total volume of the polar ice caps or of the continental glaciers could be an indication of an enhanced greenhouse effect. We will search for the effects of changes in ice volume using, primarily, the time-dependent gravitational field coefficients. We will supplement those data with Earth rotation information.

W92-70592 **578-32-24**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
ACTIVE/PASSIVE SEA ICE ANALYSIS
F. D. Carsey 818-354-8163

Continued research and development will be conducted in the generation of sea ice geophysical quantities from satellite data. The objective of this work is the accurate estimation of heat, brine and momentum fluxes from sea ice. The basic approach is the evolution and application of the Alaska SAR Facility Geophysical Processor System (ASF-GPS), now scheduled to begin operation in the summer of 1991, and its utilization in air-sea-ice interaction studies. Specifically we plan in 1992 to: (1) utilize the ASF-GPS with properly processed Special Sensor Microwave Imager (SSM/I) data in studies of the surface heat and brine fluxes of the Greenland Sea as part of the Greenland Sea Project; and (2) examine the requirements of input data, algorithms and data systems for the evolution of the ASF-GPS through the remainder of the decade including the flight phase of RADARSAT and Earth Observing System (Eos). In the Greenland Sea our approach is to use Synthetic Aperture Radar (SAR) data to track the ice and estimate convergence while using SSM/I data and weather analyses to estimate thickness changes with time. A key element of the flux analysis is the conversion of SSM/I Tbs to ice thickness changes; we have modeled the expected changes in Tb, and next we will devise methods to invert this method to

generate ice growth from Tb observations. This procedure is known to be non-unique; thus, techniques must be developed to narrow the ice types as much as possible. Also, the impact of errors in the ice motion field must be examined as the opening and closing determined by the motion data used to correct Tb changes for the deformation. In the short term we will use ice motion data from Advanced Very High Resolution Radiometer (AVHRR) data, just received, determined by the Danish scientists in Greeland Sea Project; later we will use ERS-1 SAR-derived data. A summer faculty visitor will address methods for treating the SSM/I data to merge it with the ASF-GPS output.

W92-70593 **578-35-01**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
SEA ICE MOTION IN THE PACIFIC SECTOR OF THE ARCTIC
R. Kwok 818-354-5614

The goal of the proposed research is to characterize sea ice motion by combining observations from ERS-1 Synthetic Aperture Radar (SAR), Advanced Very High Resolution Radiometer (AVHRR), drifting buoys, ice station observations and meteorological fields (wind, pressure). Specifically, the proposed work will focus on the seasonal and regional behavior of ice motion in the Pacific Sector of the Arctic Basin covered by the Alaska SAR Facility (ASF) mask. This sector includes parts of the central Arctic, Beufort, Chukchi and E. Siberian Seas. Sea ice motion will be partitioned into a large scale term and a small scale, perturbation term based on the above observations. The large scale analysis provides a context in which to interpret the small scale behavior. In global system science, the large scale description is relevant to ice transport processes whereas the small scale description is important for characterization of local deformation and regional flux calculations. The spatial and temporal statistics of these motion terms will be analyzed. Interactions between the large scale and small scale motions will be quantified. Opening/closing calculations based entirely on kinematics will be compared with direct observations. Since E-ERS1 is one of the first missions to generate routine ice observations, it is also the intention of the studies to characterize the sensitivity of the geophysical measurements to errors in the observations from Synthetic Aperture Radar. The approach of the proposed work is to characterize sea ice motion using motion fields derived from ERS-1 Synthetic Aperture Radar (SAR) data, AVHRR data and drifting buoy data. We propose to combine these observations with ice station and meteorological observations to study the motion field in the Arctic at different length scales, from kilometers to thousands of kilometers. Specifically, we propose to study the regional and seasonal behavior of the ice motion in the Pacific Sector of the Arctic Basin. We will use the geophysical products as well as image products from the Alaska SAR Facility (ASF).

W92-70594 **578-35-02**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
MAPPING OF THE GREENLAND ICE SHEET: A CONTRIBUTION TO THE MONITORING OF GLOBAL CLIMATE
R. Kwok 818-354-5614

It is proposed to use Synthetic Aperture Radar (SAR) data from the ERS-1 satellite to map the different physical and hydrologic boundaries of the Greenland ice sheet. The digital data set produced will consist of the geographic positions of the ice sheet margin and the boundaries between the various hydrologic zones on the ice sheet, as well as a 100-meter resolution mosaic of the ice sheet. The ice margin data will be compared with previous positions digitized from the published maps to identify sites of major change. The data set of zonal boundaries will form a basis for monitoring their positions by subsequent mapping by the ERS-1 and other spaceborne SAR's. Finally, temporal monitoring on a monthly basis at four selected sites will be undertaken to investigate the nature and quantitative effect of seasonal changes on the backscatter signal. The approach is to develop techniques for mapping and change detection of SAR imagery. The primary tasks include: (1) implementation of geocoding, terrain correction and mosaicking software to efficiently handle image data distributed by ESA; (2) compilation of the digital terrain data of the ice sheet; and (3) develop image analysis techniques for location of the zone boundaries in the SAR imagery.

W92-70595 **578-35-04**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
MONITORING THE SEASONAL CYCLE OF SEA ICE IN THE ARCTIC BASIN FOR CLIMATE CHANGE WITH ERS-1 SAR
B. M. Holt 818-354-5473

The principal task is to identify and monitor key seasonal transitions in the ice conditions in the Arctic Ocean that are discernible in ERS-1 C-band Synthetic Aperture Radar (SAR) imagery. The near-term objective is to determine the capability of C-band SAR (as flown on ERS-1, the Canadian Radarsat in mid-1990's, and the planned Earth Observing System (Eos) SAR in the late 1990's) to monitor seasonal changes in sea ice and to assess the capability of the Alaska SAR Facility (ASF) ice classification algorithm for providing ice type and ice condition information. The approach will be to examine ERS-1 SAR imagery of the Arctic Ocean acquired within the ASF station mask for seasonal variations as revealed in the backscatter signatures of the major ice types. The data will be analyzed by region and season. After calibration, the SAR signatures will be compared with scatterometer-derived signatures that are being utilized as look-up tables in the classification algorithm. The capability of the algorithm to assess these seasonal changes will be determined. The SAR data will be compared with other sensor data including Special Sensor Microwave Imager (SSM/I), Advanced Very High Resolution Radiometer (AVHRR) and LANDSAT imagery for clarification of features and ice type and environmental conditions. Any available measured ice parameters obtained coincident in time and location to ERS-1 will be sought and used to verify ice type and condition. The signatures will also be compared to results of radar modeling efforts generated together with co-investigator M. Drinkwater/JPL using ice and snow surface measurements. The thinner ice types have radar returns near the radiometric noise floor of the ERS-1 SAR and will be difficult to separate. The determination of thin ice will be examined by using zones of deformation derived from the ice motion analysis as indicators of areas of potential new ice growth. Later in the study a program will be designed and coordinated with other members of the science team who have utilized the ice classification algorithm to validate the functionality of the algorithm and to determine changes to the algorithm for improving accuracies, the tracking of seasonal transitions, and replacing the scatterometer look-up tables with actual SAR-derived ice signatures.

W92-70596 **578-40-00**
Marshall Space Flight Center, Huntsville, AL.
MODELING AND DATA ANALYSIS, PHYSICAL CLIMATE AND HYDROLOGICAL SYSTEMS, MODELING
R. J. Koczor 205-544-3078

The objective of this RTOP is to conduct studies of atmospheric dynamics using numerical, experimental and analytical models. Included are studies to examine baroclinic instability and its influence on the global circulation; diabatic processes affecting the thermodynamic energy budget; and the evolution of synoptic and planetary scale waves including possible vacillation and/or scale interaction, with the objective of better defining the requirements for and applications of space-based sensor measurements. The approach will be to perform detailed analyses with theoretical models and ground-based data sets, to understand the role of latent heat release in the dynamics of cyclones; examine global atmospheric processes to gain improved understanding of the scales of motion; develop techniques for including satellite data in diagnostic procedures; and develop strategies and mission concepts to measure global scale processes from space platforms.

W92-70597 **578-41-00**
Goddard Space Flight Center, Greenbelt, MD.
CLIMATE AND HYDROLOGIC SYSTEMS MODELING AND DATA ANALYSIS
Albert Arking 301-286-7208

The objective of this study is to gain an understanding of the multi-scale interaction in the tropical atmosphere and ocean from daily to interannual time scales. The approach will be to utilize synergistic analyses and physical interpretation of space based as well as ground based observations for a global and regional scale.

W92-70598 **578-41-01**
Goddard Inst. for Space Studies, New York, NY.
GLOBAL CLIMATE MODELING
James E. Hansen 212-678-5619

The objectives of this RTOP are to develop and apply climate models to support NASA's Climate Program, particularly carrying out basic research which helps define observing systems requirements for monitoring, analysis and prediction of long-range climate change. We plan to develop climate modeling capability appropriate for analysis of long-range climate. Principal areas of model development are in the areas of moist convection and clouds, ground hydrology, surface-air exchanges, and numerical methods. The approach involves testing more realistic or accurate representations of these physical processes or numerical schemes, using the previously developed Model 2 as a control for these experiments. We plan to use the current Model 2 for climate studies aimed at obtaining a better understanding of global climate sensitivity and projections of transient climate change during the next 10 to 50 years. This includes experiments in which the global greenhouse forcing changes at a realistic rate on decadal time scales.

W92-70599 **578-41-03**
Goddard Inst. for Space Studies, New York, NY.
GREENHOUSE DETECTION AND ANALYSIS
James E. Hansen 212-678-5619

The objectives of this RTOP are to: (1) determine whether existing climate data sets contain indications of climate change on decadal and century time scales; (2) determine whether the indications from different data sets are mutually consistent; and (3) examine different climate forcings for consistency with the observed changes. The two key aspects of the approach are: (1) a quantitative comparison of temperature data sets (including meteorological station, ship, radiosonde, and satellite measurements) and analysis of the likely causes of the differences; and (2) quantitative comparison and analysis of suspected climate forcings and their simulated climate impacts, such as changes of the atmospheric ozone distribution, non-CO2 greenhouse gases, and tropospheric aerosols.

W92-70600 **578-41-39**
Goddard Space Flight Center, Greenbelt, MD.
A STUDY OF THE INTERACTIONS OF ATMOSPHERIC AND LAND SURFACE PROCESSES ON INTERANNUAL TIME SCALES
Randy Koster 301-286-7061
(578-41-06)

In this project we study the long term variability of the global hydrological cycle through numerical experiments. One of our objectives is to estimate the natural variability internal to the land-atmosphere system and to distinguish it from that arising from external sources, such as changing sea-surface temperature (SST). We also examine the sensitivity of the hydrological cycle to external perturbations. This work should help identify the land-surface properties that are important in the monitoring of long term climate change. Our approach is to couple an atmospheric general circulation model (GCM) designed for long-term climate stimulation to a fairly sophisticated land surface model (LSM) that explicitly includes the effects of vegetation on the surface energy balance. The LSM is largely a simplified version of the SiB model, structured efficiently enough to allow decadal simulations. Remotely-sensed data will help establish model boundary conditions and evaluate model output. Numerous simulations with the coupled models will then isolate the sources of natural climate variability (e.g., by deactivating variability in SST and soil moistures in separate simulations).

W92-70601 **578-41-43**
Goddard Inst. for Space Studies, New York, NY.
AN OCEAN GENERAL CIRCULATION MODEL FOR CLIMATE STUDIES
Inez Fung 212-678-5590

The objectives of this RTOP are: (1) to investigate long time-scale natural variability in the climate system; (2) to investigate air-sea interaction in the North Atlantic; and (3) to reduce numerical diffusion in coarse-resolution ocean general circulation models. The major tool will be the global 3-D oceanic general circulation model (OGCM) developed by Bryan and streamlined at the Goddard Institute for Space Science (GISS). The model will be configured for sector geometry and run for greater than 1000 years with different off-line surface forcing to investigate internal modes of variation. The model will also be coupled to the GISS atmospheric general circulation model (GCM) to understand the ocean's role in natural climate variability. Surface exchanges of heat and fresh water will be re-examined using available conventional and satellite data and constrained by an inverse calculation and transports across 24 N. The surface fluxes will be compared with those derived from the atmospheric GCM to devise strategies for understanding and eliminating climate drifts in coupled models. Higher order finite-differencing schemes will be implemented in the OGCM to reduce numerical diffusion in the current model.

W92-70602 **578-42-00**
Goddard Space Flight Center, Greenbelt, MD.
CLIMATE AND HYDROLOGIC SYSTEMS MODELING AND DATA ANALYSIS
Albert Arking 301-286-7208

The objectives of this RTOP are to: (1) understand tropical climate variability via observation and modeling; (2) identify and understand the role of hydrologic processes in the coupled ocean-land-atmosphere systems; (3) identify principal models of atmospheric teleconnection on different time scales; and (4) study the dynamics of coupled air-sea interaction in the evolution of the climate variability and sensitivity. The approach is to: (1) carry out analyses of hydrologic processes and gained understanding of the internal moist dynamical processes in the Goddard Laboratory for Atmosphere (GLA) general circulation model (GCM); (2) develop coupled ocean-land-atmosphere models for use in assessing the natural and anthropogenically induced climate variability; (3) provide advanced coupled models for use in climate predictability studies; and (4) develop off-line land surface model including vegetation control, to be included in GCM.

W92-70603 **578-42-10**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
SEASAT WIND ANALYSIS AND STUDIES
P. M. Woiceshyn 818-354-5416

Our research is directed towards the following: (1) the exploitation of high-resolution scatterometer marine wind and wind stress measurements from ERS-1 and SEASAT in global and meso-scale meteorological research, applications, analysis, and prediction; (2) the exploitation of sophisticated techniques of visualization including animation in order to gain the fullest information and insight from high-resolution global, remotely sensed data; (3) collaboration with European Center for Medium Weather Forecasts (ECMWF) and the National Research Council (CNR)-Venice in the establishment and exploitation of an ERS-1 data base, and in the enhancement of our understanding of the potential of such data; (4) development of methods for dealiasing ERS-1 and Specialized Experimental Applications Satellite (SEASAT) scatterometer wind data for assimilation into numerical weather prediction models for application to short-range forecasts; (5) characterization of the quality of the ERS-1 and SEASAT scatterometer wind retrieval systems utilizing in situ data, numerical analysis, and altimeter data with statistical packages developed by this project, ECMWF, and CNR-Venice. The above objectives require the following for implementation: (1) continuation of our research into optimal methods and algorithms for dealiasing of scatterometer wind observations and increasing the accuracy of scatterometer wind retrievals; and (2) an application of the achieved

results to the characterization and validation of ERS-1 scatterometer data in the validation phase following launch in May 1991. One of the investigators, Peter M. Woiceshyn, will spend an extended period at ECMWF with his computer workstations, (Sun, SPARC1, and NeXT), permitting near real-time validation of scatterometer data and dealiasing procedures. This is necessary because the European Space Agency (ESA) data distribution will not include all wind direction ambiguities, nor will it include the co-located in situ observations, analyses, and statistics derived during the operational cycle. The objectives will be further pursued by the following approaches: (1) collaboration with ECMWF and CNR-Venice in scientific exploitation of the data bases established from ERS-1; (2) production of two- and three-dimensional color-animated time sequences for the visualization of marine wind and other meteorological patterns on both global and meso-scales (and so designed to enhance understanding and stimulate research); and (3) the continuation of scatterometer data use in conjunction with tropospheric data in the development of scientific techniques and results, e.g., rate of rainfall estimation, tropical ocean-atmosphere dynamics, cyclogenesis, short-range forecasting.

W92-70604 **578-42-10**
Marshall Space Flight Center, Huntsville, AL.
EARTH SCIENCE AND APPLICATIONS ADVANCED MISSIONS STUDIES
R. G. Beranek 205-544-0624
(578-42-13)

The objectives of this RTOP are to: (1) maintain smooth and efficient performance of advanced missions studies for Earth Science and Applications candidate future space missions; and (2) continue systems and subsystems concept studies related to the Geostationary Earth Observatory (GEO), the Laser Atmospheric Wind Sounder Carrier and other future Earth Science and Applications missions related to the Mission to Planet Earth Initiative. In support of the future Earth Science and Applications missions, we plan to: (1) perform selected studies to define observatory and carrier concept configurations which will accomplish scientific mission objectives; (2) continue to refine these configurations and subsystems performance characteristics as science/payload requirements evolve; (3) develop programmatic data on estimated costs and schedules required to support hardware development activities associated with these missions; (4) actively participate in Science Steering Committees and Working Groups for accommodations/science requirements discussions; and (5) prepare for initiation of concept definition activities.

W92-70605 **578-81-16**
Goddard Space Flight Center, Greenbelt, MD.
GLOBAL HYDROLOGIC CYCLE
Albert Arking 301-286-7208
(428-81-16; 479-81-16)

The objective of this RTOP is to improve our understanding of the: (1) physical mechanisms of atmospheric hydrologic processes; (2) role of hydrologic processes in large scale ocean-atmosphere-land interaction leading to natural fluctuation of the global climate system over a variety of time scales; and (3) role of land surface processes, including storage, in the global hydrologic cycle, with emphasis on the interaction and integration of regional to global scales. This will be achieved through extensive use of data collected from existing satellite missions and from the Earth Observatory System (EOS). Results obtained for the pre-EOS phase will be used to provide guidance for instrument design in the launch phase and to further our understanding of global hydrologic processes through model development and data analysis. A synergistic approach based on analysis of data from space and non-space platforms as well as modeling will be emphasized.

W92-70606 **578-97-10**
Goddard Space Flight Center, Greenbelt, MD.
SCIENCE COMMUNICATIONS
Robert G. Kirk 301-286-7895

This RTOP covers communications support for NASA Science Working Groups and in-house management persons to support agency-wide flight project science support.

W92-70607 **578-97-11**
Goddard Space Flight Center, Greenbelt, MD.
UCAR/OFFICE OF INTERDISCIPLINARY EARTH STUDIES (OIES) SUPPORT
Otto W. Thiele 301-286-9006

The objective of this RTOP is to support University Corporation for Atmospheric Research/Office of Interdisciplinary Earth Studies (UCAR/OIES) for NASA Headquarters, through a cooperative agreement, to study approaches for advancing interdisciplinary research in Earth system science. To accomplish this, OIES will address a set of scientific themes that are particularly in need of interdisciplinary coordination, that are central to the goals of the U.S. Global Change Program and that are germane to the goals of NASA and GSFC.

W92-70608 **578-97-12**
Goddard Space Flight Center, Greenbelt, MD.
HYDROSPHERIC PROCESSES PROGRAM SUPPORT FOR MODELING AND DATA ANALYSIS
Antonio J. Busalacchi 301-286-6171

The objective of this RTOP is to support modeling and data analysis research activities in the Goddard Laboratory for Hydrospheric Processes.

W92-70609 **578-97-51**
Marshall Space Flight Center, Huntsville, AL.
MODELING AND DATA ANALYSIS, CLIMATE AND HYDROLOGY CRYOSPHERE STUDIES
R. J. Koczor 205-544-3078

The objectives of this RTOP are to: (1) perform fundamental studies aimed at improving our understanding of the impact of the cryosphere on the Earth's climate and hydrology; and (2) establish a coordinated modeling and data analysis program with NASA Headquarters, NASA Centers, and non-government research institutions.

Biogeochemistry and Geophysics Modeling and Data Analysis

W92-70610 **579-11-00**
Goddard Space Flight Center, Greenbelt, MD.
OCEAN COLOR
Charles R. McClain 301-286-5377

This RTOP contains tasks that: (1) apply ocean color data and related environmental data sets to investigations of oceanic processes; (2) develop software and hardware systems for the analyses of those data sets; and (3) maintain the existing Laboratory for Oceans Computer Facility where the above tasks are performed. Because data analysis and interpretation are closely connected to analysis software and hardware systems, the tasks under this RTOP consist of both science applications and system development/maintenance. Experience has shown that the most efficient and productive computing scenario is one that allows the scientists to participate and even oversee the computing environment in which they work. In this RTOP, the science tasks focus on the couplings between biological and physical oceanic processes.

W92-70611 **579-20-00**
Langley Research Center, Hampton, VA.
BIOGEOCHEMISTRY AND GEOPHYSICS/MODELING AND DATA ANALYSIS
Ellis E. Remsberg 804-864-5823

The objective of this RTOP is the application of remote sensing technology and measurements to environmental monitoring of the middle atmosphere. Data analysis techniques and comparisons with models will be used to improve our understanding of the middle atmosphere and potential changes to its composition and structure. Specific tasks include: (1) the interpretation of chemistry and transport processes in the middle atmosphere using constituent and temperature data from satellite-based experiments; (2) the analysis and comparison of satellite and ground-based data sets for stratospheric NO2; (3) an analysis of Stratospheric Aerosol and Gas Experiment (SAGE)/SAGE2 ozone and Total Ozone Mapping Spectrometer (TOMS) Version 6 ozone to estimate regional to global-scale variations in tropospheric ozone; (4) empirical model studies of perturbations and trends in middle atmosphere ozone and temperatures, plus the isolation of effects of solar ultraviolet (UV) forcing; (5) maintenance of a pilot electronic data base consisting of middle atmosphere trace gas data, plus temperature and geopotential height from both measurements and models to facilitate rapid dissemination of data to the scientific community and to support data and 2-D model intercomparisons; (6) the analysis and modeling of observations of vertically propagating waves in the tropics; (7) the modification of the existing LaRC general circulation model (GCM) by incorporation of a complete tropospheric physics package, plus an update of the tropospheric chemistry module.

W92-70612 **579-21-00**
Goddard Space Flight Center, Greenbelt, MD.
ATMOSPHERIC CHEMISTRY DATA ANALYSIS
Richard B. Rood 301-286-8203

The objective of this RTOP is to enhance our understanding of the behavior of atmospheric composition and dynamics over time scales from days to decades. The approach is to: (1) conduct analyses of data obtained by satellite-based remote sensors using models of latitudinal, zonal, and temporal variability and theoretical models of radiation transfer and photochemical production, loss, and transport; (2) assemble long term climatological data sets for the study of annual and interannual variations and their driving mechanisms, plus responses to solar activity; and (3) conduct analyses of aircraft and balloon data, with particular emphasis on the process involved in the maintenance of tropospheric and stratospheric composition.

W92-70613 **579-21-53**
Wallops Flight Facility, Wallops Island, VA.
SATELLITE MEASUREMENTS OF NATAL: MULTIPLE-SATELLITE OZONE DATA SET
A. L. Torres 804-824-1553

The objective of this proposal is to investigate time-dependent differences among satellite-based ozone instruments. This study will help validate their use in producing long-term data sets for studying global changes. An integrated time series of data from satellite, rocket, and balloon measurements of ozone at Natal, Brazil, will be created and analyzed. The time period will extend over 14 years, from the start of Solar Backscattered Ultraviolet (SBUV) ozone measurements on Nimbus 7 (1978) to the period of Upper Atmosphere Research Satellite (UARS) measurements in 1992. Detailed intercomparisons between data obtained with SBUV, SBUV/2, Solar Mesosphere Explorer (SME), Stratospheric Aerosol and Gas Experiment (SAGE)2, rocket, and balloon instruments will be carried out. Particular emphasis will be placed on the effects of uncertainties in pressure/temperature profiles on the intercomparison of fundamentally different instruments.

W92-70614 **579-22-00**
Ames Research Center, Moffett Field, CA.
THEORETICAL INVESTIGATION OF STRATOSPHERIC PARTICULATES
O. B. Toon 415-604-5971

The objective of the work is to contribute to NASA's Atmospheric Chemistry Modeling and Analysis Program in the area of quantifying the importance of heterogenous chemistry. A sophisticated model of polar stratospheric clouds has been developed and used to study the properties of ice clouds and nitric acid clouds. The model has been used to investigate the mechanisms of stratospheric denitrification. Also included is a meteorological support task to manage and distribute data from aircraft field programs. Meteorological data including conventional global analyses and forecasts, and satellite cloud imagery is supplied to the field programs via NASA internet links into a field local area network (LAN) and direct satellite downlink. The field mission data is archived and published on compact disk read-only memory (CDROM) for distribution to the field participants and the community.

W92-70615 **579-22-20**
Goddard Space Flight Center, Greenbelt, MD.
ATMOSPHERIC CHEMISTRY DATA ANALYSIS
Paul A. Newman 301-286-3806

The objectives of this RTOP are to: (1) enhance our understanding of the behavior of stratospheric composition and temperature over time scales of the 27-day solar rotation period, the annual cycle, and the 11-year solar cycle; and (2) delineate the driving mechanisms of these variations. The approach is to: (1) conduct analyses of data obtained by satellite-based remote sensors using models of latitudinal, zonal, and temporal variability and theoretical models of radiation transfer and photochemical production, loss, and transport; and (2) assemble long term climatological data sets for the study of annual and interannual variations and their driving mechanisms, plus responses to solar activity.

W92-70616 **579-23-00**
Goddard Space Flight Center, Greenbelt, MD.
UPPER ATMOSPHERE RESEARCH - TWO-DIMENSIONAL MODELING
Charles H. Jackman 301-286-8399
(579-24-00)

The objectives of this RTOP are to: (1) provide a framework for developing and understanding an organized, solid body of knowledge of the physics, chemistry, and dynamics of the Earth's upper atmosphere; (2) analyze data from upper atmospheric flight programs; and (3) predict and assess the effects of natural and man-related perturbations on the atmosphere. The approach is to: (1) continue to develop and utilize two-dimensional models of upper atmospheric photochemistry, radiation, and dynamics; and (2) utilize satellite and field measurement data to elucidate the controlling mechanisms for atmospheric composition and variations.

W92-70617 **579-23-01**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
TWO-DIMENSIONAL STRATOSPHERIC CHEMICAL MODEL - RADIATION
D. Crisp 818-354-2224

The distribution of ozone and other important stratospheric trace gases is controlled by the coupled effects of chemical, dynamical, and radiative processes. A detailed description of each process is needed to diagnose the present state of the stratosphere, and to assess the impact of natural and anthropogenic modifications to this system. The principal objective of this RTOP is to develop improved numerical radiative transfer models for finding solar heating rates, thermal cooling rates, and the diabatic circulation at these levels of the atmosphere. These models should include all radiative processes that are known to be important in the stratosphere, including absorption, emission, and multiple scattering of gases (H2O, CO2, O3, N2O, CH4, O2, and NO2), aerosols, and clouds. The current radiative transfer

model has provided benchmarks for the simpler radiative transfer algorithms that are used by other 2-D modeling groups, and has been used to generate net radiative heating rates for use in the Caltech 2-D chemical tracer transport model. It is currently undergoing major modifications to increase its speed, accuracy, and versatility. The original Voigt Quasi-Random Model is being replaced by a new class of methods called spectral mapping transformations (SMT's), that were developed as part of this program. Preliminary tests of this new method have demonstrated accuracies comparable to those of line-by-line models, and speeds like those obtained with simpler band models. Results from the new radiative transfer model will be incorporated into the Caltech/JPL 2-D chemical tracer transport model for simulations of the stratospheric hydrological cycle. The work supported by this RTOP is part of a continuing collaboration between investigators at Caltech and JPL.

W92-70618 **579-23-10**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
TWO-DIMENSIONAL STRATOSPHERIC CHEMICAL MODEL - DYNAMICS
R. W. Zurek 818-354-3725

The objectives of this RTOP are to understand quantitatively the structure and circulation of the upper atmosphere and the distribution there of photochemically or radiatively important trace gases, as revealed by various remote sensors (LIMB Infrared Monitoring of the Stratosphere (LIMS), Stratospheric and Mesospheric Sounder (SAMS), Atmospheric Trace Molecule Spectroscopy (ATMOS), etc). This is done through numerical simulations of the observed tracer distributions, using one- and two-dimensional models of coupled photochemical, dynamical, and radiative processes, together with diagnostic analysis of observations provided by ground-based, balloon-borne, aircraft, and satellite instruments. The work supported by this RTOP is part of a continuing collaboration between investigators at Caltech and JPL.

W92-70619 **579-24-00**
Ames Research Center, Moffett Field, CA.
SIMULATION OF TROPOSPHERIC OZONE
R. B. Chatfield 415-604-5490

The objective of this program is to contribute to NASA's Atmospheric Chemistry Modeling and Data Analysis Program in the area of quantifying the effect of biomass burning and other emissions upon tropospheric radiatively active gases like ozone and methane, through computer simulation of these gases and associated gases that determine their levels. The approach is to construct, test, and apply one-, two-, and three-dimensional models of tropospheric trace species as they are photochemically transformed and transported away from their source regions. Emphasis is on large regional modeling and global-scale effects. The effort will be to construct the models, run the computer simulation models, and analyze the results for publication and comparison to remote-sensing and in-situ samples of tropospheric composition.

W92-70620 **579-24-00**
Goddard Space Flight Center, Greenbelt, MD.
STRATOSPHERIC MODELING
Richard B. Rood 301-286-8203
(579-21-00; 579-23-00)

This is a collection of efforts to model stratospheric phenomena and interpret stratospheric data by use of model results. It is felt that parallel efforts in modeling and data analysis provide the best mechanism for understanding data and improving models. The primary focus is on three-dimensional (3-D) modeling, with use of 2-D, 1-D, and mechanistic models when appropriate. The current goal is to simulate stratospheric circulation and chemistry as realistically as possible. Winds from the data assimilation STRATAN are being used. Given the fundamental problems of general circulation models (GCM's), it is felt that that approach offers a unique attack to understanding stratospheric data and ultimately to the improvement of GCM's. Presently we are performing simulations to investigate the interaction of the wintertime polar vortex with middle latitudes. We are also focussing on Upper Atmosphere Research Satellite (UARS) related experiments. We actively participate in High Speed Research Program (HSRP), Earth Observing System (EOS), and the Network for the Detection of Stratospheric Change (NDSC). Complete reprocessing of the past 1978 National Meteorological Center (NMC) data, with quality checks, is progressing.

W92-70621 **579-24-06**
Goddard Inst. for Space Studies, New York, NY.
GLOBAL TROPOSPHERIC MODELING OF TRACE GASES
Michael Prather 212-678-5625

The objectives of this RTOP are to: (1) contribute to an understanding of global budgets for chemically and radiatively important trace gases and to an assessment of human impact on atmospheric composition; and (2) determine measurement requirements and sampling strategies for tropospheric chemistry program, and aid in interpretation of observations. A series of studies is being/has been made with a 3-D Chemical Transport Model (CTM) developed from the Goddard Institute for Space Science (GISS) General Circulation Model and in collaboration with colleagues at Harvard University. The approach has been progressive; successive studies of different chemical species have led to a better understanding and calibration of the CTM: (1) chlorofluorocarbons (Done); (2) krypton-85 (Done); (3) radon (Done); (4) methylchloroform (Done); (5) methane (Done); (6) carbon monoxide (in progress); and (7) odd nitrogen and ozone (in progress/planning).

W92-70622 **579-24-07**
Goddard Inst. for Space Studies, New York, NY.
STRATOSPHERIC CHEMISTRY IN A GCM
Michael Prather 212-678-5625

This research focuses on the development of 3-D Chemical Transport Models (CTM) for the stratosphere, based on the general circulation model for the middle atmosphere already developed at Goddard Institute for Space Science (GISS). For stratospheric GCM development see RTOP 579-24-09-03. The CTM has been used to study the infall of meteoric material (Prather and Rodriguez, 1988), the dynamical mixing of the Antarctic ozone hole (Prather et al., 1990), and the stratospheric distribution of N2O (Garcia and Prather, 1991). Task 1 is to extend to the N2O-NOy coupled system and to the halocarbon-Cl(y) system. The CTM will also be applied to problems of current interest such as studying the fate of emissions from high altitude aircraft. Task 2 is on Stratospheric Chemistry: particular effort is placed on model analysis of the measured tracer cross correlations. The linearization of ozone photochemistry is extended to include variations in temperature, overhead ozone column and NO(y). Task 3 is on Perturbed Atmospheres: how the changes in stratospheric circulation (2xCO2, etc.) would impact the lifetimes of long lived tracers (N2O and CFCs) and the ozone columns will be assessed.

W92-70623 **579-24-09**
Goddard Inst. for Space Studies, New York, NY.
CLIMATOLOGICAL STRATOSPHERIC MODELING
David Rind 2120678-5593

The objectives of this RTOP are as follows: (1) contributions will be made toward understanding the impact of potential climate perturbations on the stratosphere; (2) assessment will be made of the effect of any alterations in stratospheric dynamics on the impact of anthropogenic releases on stratospheric ozone; and (3) a better understanding of the expected changes to be observed in the next several decades will be attempted. The approach will be 3-D modeling of the troposphere/stratosphere/mesosphere system to deliniate climate change influence on the stratosphere; results saved for use with photochemical models.

W92-70624 **579-31-01**
Goddard Space Flight Center, Greenbelt, MD.
PROBLEMS IN INTERPRETING SATELLITE CRUSTAL ANOMALY FIELD DATA
Robert A. Langel 301-286-6603

The basic objective of the program is to isolate crustal fields from the core and external fields and to model the isolated crustal fields in terms of geophysical parameters. This requires understanding the nature and limitations of satellite magnetic field data, collection of and comparison with data from aeromagnetic and ship magnetic surveys, and evaluation of the effects of external fields. Consequences of satellite data limitations for interpretation are to be discovered. The approach consists of (1) the development of suitable data selection and filtering criteria, (2) estimating or modeling external fields and correcting the data where possible, (3) collecting and collating alternative data for comparison and joint analysis, and (4) developing and evaluating analysis techniques.

W92-70625 **579-31-02**
Goddard Space Flight Center, Greenbelt, MD.
MODELING OF THE MAIN MAGNETIC FIELD
Robert A. Langel 301-286-6603

The major objectives of this RTOP are to develop improved methods and techniques for the analysis and determination of the geomagnetic field and its temporal change; to test those methods and techniques by derivation of models of the Earth's field and its temporal variation; and, as appropriate, use the resulting models to study the processes in the core which are responsible for generation of that field and the conductivity of the mantle through which the time varying field passes. For focus, the specific research goal for FY-92 to FY-94 is to derive a definitive model of the geomagnetic field for the period 1900 through 1992, including representation of low degree external terms and including an error model. The research will proceed along three directions simultaneously: (1) development of data weighting and error model; (2) extension of external field representation; and (3) investigation of parameterization of temporal change. Error Analysis: Methods proposed for dealing with the presence of crustal and external fields will be compared, evaluated, and, as appropriate, implemented. A better understanding of the statistics of crustal and external fields will be pursued both theoretically and by analysis of the spectral properties of aeromagnetic and marine magnetic data. Existing error formalisms will be extended. External Field: The currently used method of setting the external spherical harmonic coefficients proportional to the Dst index will be extended to use either sunspot number or the aa index in place of Dst, permitting extension of the method to earlier epochs when Dst is not available. The appropriate degree and order of external terms will be re-examined. Temporal Change: Three alternative approaches to the usual Taylor series will be explored. The first is strictly mathematically based and uses spline functions. The second and third are based on theories of the generation of the geomagnetic temporal variations.

W92-70626 **579-31-04**
Goddard Space Flight Center, Greenbelt, MD.
GEOMAGNETIC BASELINE ANALYSIS AND DATA BASE
Robert A. Langel 301-286-6603
(579-31-01; 579-31-02)

The major objectives of this RTOP are to (1) maintain the NASA/GSFC data base of near-Earth satellite magnetic field data from the Polar Orbiting Geophysical Observatory (POGO) and MAGSAT spacecraft; (2) maintain and upgrade the software and data base necessary to produce state of the art models of the main geomagnetic field both for modeling research and for applications requiring field models, e.g., the International Geomagnetic Reference Field (IGRF); (3) maintain and upgrade software previously developed for analysis and display of satellite magnetic anomaly data; (4) to distribute such data and software to the scientific public as requests are made; and (5) to conduct studies preparatory to proposed missions. For the POGO and MAGSAT data a tape/cartridge library is maintained, including catalog, of both the original data after basic processing and of specially processed data. As needed the data are converted from one media to another, e.g., for the past two years the tape library has been under conversion to cartridges. For main field studies, all suitable data types are collected, quality checked and corrected, and suitably formatted. New observatory, repeat and survey data are added to our data set as they become available. The usefulness of data from other satellites (POGS, Dynamics Explorer-1 (DE-1)) is being investigated, and, if appropriate, the data will be added to the data base. With Environmental Data and Information Service EDIS/NOAA, reduction of the marine magnetic data set through 1987 for use in main field modeling was completed and published. This effort continues with attempts to acquire additional marine data and process it as available. Software is maintained both on disk and cartridge in source and object form. When necessary it is converted to new computer systems, e.g., the recent conversion from the CYBER 205 to the Cray. Additional documentation is required. During FY-89 to 91 a total rewrite and modernization of the field modeling software (the FIT system) was tested; a model was derived for use in a Space Defense Initiative (SDI) particle beam experiment; and models were submitted to International Association of Geomagnetism and Aeronomy (IAGA) as candidates for the 1985 Definitive Geomagnetic Reference Field (DGRF) and 1990 IGRF.

W92-70627 **579-32-00**
Goddard Space Flight Center, Greenbelt, MD.
CRUSTAL DYNAMICS SCIENTIFIC COMPUTER SUPPORT
Patrick H. McClain 301-286-2158

The purpose of data management is to use mainly the NCCS computer systems to take GEODYN analysis of laser measurements and produce precise geodetic station coordinates. The data reduction process includes the orbital analysis of the Laser Geodynamic Satellite (LAGEOS) ranging data and the results are enhancements to mathematical models. LAGEOS data has been re-analyzed in a global solution (SL7) for plate motion and regional deformation. GEODYN and other related programs such as SOLVE produce station positions for the tracking network, determine polar motion, earth rotation tidal parameters, gravity models, GM, length-of-day and earth orientation parameters, etc., from satellite data. These processes require a tremendous amount of computing capability, computer allocations and data storage capability. The efforts include the use of the IBM3081 and CRAY Y-MP8. The vector processing capabilities at the NCCS have been used extensively to produce significant analysis and results for the on going Crustal Dynamics and earth modeling investigations. Essential for continuing improvements is the new supercomputer, the CRAY Y-MP8/432, which allows for faster and more accurate computing, the use of greater amounts of data, swifter turn around and combined with the IBM3081 and Terabyte machine provides a vast array of storage. This development will allow improvements in computer networking for more efficient distribution of the data to the laser and other analysis groups; improvement in methods of using data development of new software programs; and the improvement of the earth and ocean tidal models.

W92-70628 **579-32-01**
Goddard Space Flight Center, Greenbelt, MD.
GRAVITY FIELD AND GEOID
Barbara H. Putney 301-286-8671
(465-17-00; 579-32-00)

The objective of this RTOP is the development of an improved model of the Earth's gravity field in combination with a model for the ocean tides, and a model for the dynamic ocean topography. The gravity, tidal and ocean topography models are derived from a combination of tracking data, altimetry, and surface measurements. GEODYN, ERODYN and SOLVE programs to support this research will be designed and implemented. In order to better represent the short wavelengths in the gravity field of the Earth, the new field will be larger in degree and order than previous models (approx. 70x70). Primary emphasis will be placed on the incorporation of the high quality laser tracking data being acquired by NASA Crustal Dynamics Project, and the altimetry

data from past and upcoming spacecraft. Extended force models for the dynamic polar motion, relativity, etc. will be incorporated into the solution so as to improve the modeling and understanding for the Earth and spacecraft motions. This activity is the geophysical component of a joint modeling and research program by the cognizant NASA Earth and Oceans Program offices. Required software enhancements will be designed and implemented to support the state-of-the-art modeling.

W92-70629 **579-32-06**
Goddard Space Flight Center, Greenbelt, MD.
CRUSTAL DYNAMICS DATA INFORMATION SYSTEM (CDDIS)
Carey E. Noll 301-286-9283

The CDDIS data system RTOP was formerly a sub-task of the Crustal Dynamics Project (CDP) RTOP. This RTOP will continue to fully support the data archiving and distribution requirements of the CDP through December 1991. At that time, the CDP formally comes to an end and its successor, the Dynamics of the Solid Earth (DOSE) begins. The Crustal Dynamics Project was formed by NASA to apply space methods and technology to advance the scientific understanding of Earth dynamics, tectonophysics, and earthquake mechanisms. The Project uses three types of space-age techniques in this study: laser ranging to an artificial satellite or the moon, very long baseline interferometry (VLBI), and the global positioning system (GPS). As part of its data management, the Project has designed and implemented a centralized Crustal Dynamics Data Information System (CDDIS). The CDDIS has been fully operational since September, 1982. The main purpose of the CDDIS is to store all geodetic data products in a central data bank and maintain information about the archival of these data. The CDDIS is also tasked to disseminate these data products to Project investigators and cooperating institutions. The laser, VLBI, and GPS data sets accessible through the CDDIS fall into four major categories: preprocessed (Level 1), analyzed (Level 2 and 3), ancillary, and Project management data. The CDDIS is operational on a DEC Micro VAX II computer with nearly two gbytes of on-line magnetic disk storage and 650 mbytes of on-line of optical disk storage (an additional 650 mbytes is near-line). The CDDIS is accessible to all investigators from remote, worldwide locations through NSI-DECnet (formerly known as SPAN), NSI-TCP/IP, and BITnet networks, through GTE TELENET, and through dial-in service.

W92-70630 **579-33-00**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
ATMOSPHERIC EXCITATION OF EARTH ROTATION AND POLAR MOTION
J. O. Dickey 818-354-3235

The atmospheric excitation plan has several thrusts: (1) investigation into the origin and dynamics of the intraseasonal 40 to 50 day oscillation in Earth rotation and atmospheric angular momentum (AAM); (2) study of the atmospheric excitation of interannual variations in Earth rotation and polar motion and their connection with the ENSO (El Nino/Southern Oscillation) and QBO (Quasi-Biennial Oscillation) phenomena; and (3) the study of solid Earth-atmosphere interaction, via both the angular momentum balance and torque approaches. Length Of Day (LOD) and Atmospheric Angular Momentum (AAM) has been explored. The connection between angular momentum exchange on the interannual time frame and the Southern Oscillation and related El Nino phenomena has been pursued with an updated analysis. In a case study of the 1982 to 1983 El Nino event, we have determined that the stratosphere plays a significant role in interannual variations with the atmosphere integrated to 1 mb explaining approx. 90 pct. of the interannual LOD variations. Coherence was established between LOD and AAM down to 8 days. Lack of coherence at short periods was caused by a signal-to-noise problem, as shown by the spectral modeling. Inadequacies for the currently accepted tidal models have been discovered; incorporation of the effects of ocean tidal currents as proposed by Brosche et al. (1989) resolve this situation. The results of the UCLA General Circulation Model (GCM) have been studied to investigate the origin of the 40 to 50 day oscillation seen both in the LOD and AAM data. The investigators have conducted several detailed intercomparisons of atmospheric excitation estimates from the various centers, and comparisons with geodetic data. Progress is planned toward several thrusts, among others: (1) a three-year no-mountain run will be analyzed to study the origin of the intraseasonal 40 to 50 day variation; (2) a detailed analysis of the 1988 episode, using gridded atmospheric data to diagnose meridional fluxes of momentum and energy between the tropics and extratropics; (3) innovative statistical techniques, such as singular spectral analysis, will be applied to LOD and AAM to decompose these series into their empirical orthogonal functions (EOFs) and principal components (PCs) with respect to temporal variability; dominant statistical features will be related to physical and dynamical mechanisms; and (4) investigate the relationships between global average temperatures, pole-to-equator temperature gradient and Earth rotation variations.

W92-70631 **579-33-00**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
RAPID EARTH ORIENTATION CHANGES
J. O. Dickey 818-354-3235

The objective of this RTOP is to observe and understand the interactions of the atmosphere and ocean with rotational dynamics of the Earth, and their contributions to the excitation of Earth orientation variations over time scales of hours to months. The approach will be to: (1) study the Earth's Angular Momentum Budget (both axially and non-axially) at high frequencies through time series analyses of length-of-day (LOD), polar motion, and atmospheric angular momentum (AAM) as well as through spectral and coherency analyses in the frequency domain, stochastically model the LOD, polar motion and AAM variations (both the processes themselves and the associated measurement noises), study the coherence between series and their causes; (2) quantify the role of the atmosphere and oceans in the Earth orientation variations at high frequencies, and study the appropriateness of the inverted barometer approximation at high frequencies; (3) study short-period Earth orientation variations induced by the atmosphere using atmospheric general circulation models; (4) study the role of mountain torque and wind stress on solid Earth-atmosphere interactions using geodetic determinations studied in concert with results from both numerical simulations and operational analyses, focusing on periods of one month or less; (5) improve models of the effects of tidal forces on the Earth's rotation (primarily at periods less than monthly); and (6) improve the theory of the Earth's rotation, especially at high frequencies, and reconsider the separation between nearly diurnal polar motion and nutation and reconcile the difference between what is observed (the Celestial Ephemeris Pole) and the theoretical formulation (which is in terms of the rotation vector).

W92-70632 **579-33-01**
Goddard Space Flight Center, Greenbelt, MD.
GEOMAGNETIC MODELING OF CORE FLUID MOTIONS
Coerte V. Voorhies 301-286-3530
(579-31-02)

The objective is to improve quantitative explication of global geomagnetic change in terms of its origin as an imbalance between motional induction and magnetic diffusion near the top of Earth's electrically conducting liquid outer core and the diffusion of this signal through the rigid, electrically resistive mantle. Technical objectives are to: (1) improve steady core surface flow estimates by allowing for mantle conductivity, core asphericity, and an uncertain initial core field; (2) estimate deep mantle conductivity; and (3) study slowly varying core surface flow. The plan is to derive steady core surface flows from the Definitive Geomagnetic Reference Field (DGRF) models (IAGA, 1988) for several mantle conductivity profiles using damped, weighted least squares. We seek the profile giving the best fit at a fixed, modest level of flow complexity. The formalism allows derivation of both an initial core field model and a steady flow; the modified code should be ready by the start of FY-92. The initial field and flow are to be derived from the data, rather than DGRF models. Slowly varying core flow estimation is to be pursued.

W92-70633 **579-34-01**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
IMAGE PROCESSING CAPABILITY UPGRADE
R. E. Alley 818-354-6363

The objective of this work is to upgrade the facilities available to the geology group for image processing and for analysis of field samples. The current operational image processing and analysis computer system consists of a Sun Sparcserver 4/370, with 2.2 gigabytes of disk storage, two triple density tape drives, one 1/4-inch cartridge tape drive, and an image processing workstation. Access may be accomplished directly via 10 terminals, by telephone modem, or indirectly via the ILAN (local area network), INTERNET, or DECnet networks. Current problems to be addressed involve the need to move data conveniently to and from the floppy disks used by field instruments and by investigators at other sites; the need to ingest maps (and sometimes photographs) into the system to be combined with data from other sources; the need for a more compact and convenient archive and retrieval system; and the unending need for more on-line and rapid access mountable mass storage. The planned upgrades to this facility include a Compact Disk-Read Only Memory (CD-ROM) drive, a read-write optical disk drive, an 8 mm cartridge tape drive, and 700 megabytes of additional permanent disk storage. Most of these upgrades should be completed by the end of FY-91. During FY-92, the geology group will need to purchase a DR11W controller, enabling it to use an additional color image display device, and a personal computer. The personal computer will be connected to the Sun (and beyond) by network, and its primary function will be to support data transfer by floppy disks (both sizes, multiple densities) and to provide a platform for personal computer software as needed. A document (map) scanning device will also be added, either directly to the Sun or to the personal computer. Supplies and maintenance services for the Sun computer and the Beckman visible-near infrared spectrophotometer will need to be provided.

W92-70634 **579-41-00**
Ames Research Center, Moffett Field, CA.
IMAGE PROCESSING LABORATORY FOR TERRESTRIAL ECOLOGY
K. J. Weinstock 415-604-3327

The objective of this work is to provide general support to NASA's science program in Terrestrial Remote Sensing. This RTOP will insure that supplementary support is provided for the operation of Ames Research Center's (ARC) Image Processing Laboratory (IPL) and will contribute toward development of new capabilities for the analysis of remote sensing and ecological data by incoming senior scientists. The approach will be to provide support to the IPL in the form of funding for ongoing computer equipment replacement and upgrades and for one-time additions of specific state-of-the-art equipment.

W92-70635 **579-41-02**
Goddard Space Flight Center, Greenbelt, MD.
GLOBAL INVENTORY MONITORING AND MODELING EXPERIMENT
Compton J. Tucker 301-286-7122

The objective is to develop the techniques and scientific basis for studying terrestrial renewable resources at regional, continental, and global scales with multilevel satellite remote sensing data. Satellite data will be obtained at spatial resolutions of 30 m, 80 m, 1 km, 4 km, and 15 km for selected local areas (30 and 80 m), regional test sites (1km), continental test areas (4 and 8 km), and the entire planet (15 km). These data will be analyzed to provide high temporal frequency vegetation biomass and condition information for assessing productivity, land cover mapping, deforestation, insect and disease upsurges, and other large scale vegetation information of interest to global science questions such as the earth's radiation budget, the carbon cycle, and the hydrological cycle.

W92-70636 **579-41-04**
Goddard Space Flight Center, Greenbelt, MD.
LTP COMPUTER SUPPORT
Edward Masuoka 301-286-7608

The objective is to provide the best possible computing environment for scientists in the Laboratory for Terrestrial Physics, who are conducting research in Land Processes. The following approaches will be used: (1) create a powerful computing environment in the Laboratory computer facility by integrating UNIX workstations into the VAXcluster as compute and file servers and image analysis stations; (2) provide system administrations and networking support for scientists with UNIX workstations; (3) improve analysis capabilities of existing workstations by providing programmer support to assist scientists working with a common suite of software for graphics and image processing; (4) assist RTOP managers by providing timely financial data through an on-line database maintained on the LTP VAXcluster and networked Macintosh computers; and (5) operate a VAX mini-computer to support scientists working on the BOREAS project.

W92-70637 **579-41-08**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
ERS-1 STUDIES OF FOREST ECOSYSTEMS
J. B. Way 818-354-8225
(462-41-61)

Multitemporal measurement of forest ecosystems may be critical in resolving ambiguous interpretations of microwave backscattering from architecturally complicated forest canopies in the presence of spatial and temporal variability in scene characteristics. It is postulated that multitemporal microwave observations can be utilized to separate weather related scene variance from phenologic development. In addition, changing seasonal environmental conditions enhance or subdue certain components of the radar backscatter. The primary objective of this effort is to collect, calibrate and analyze the ESA Remote Sensing Satellite-1 (ERS-1) image data to be used in studying temporal change (phenologic and environmental) in forest ecosystems. A related RTOP (462-41-61) under Dr. Diane Wickland's program addresses the collection of associated ground truth and modeling of the canopy data to predict multi-seasonal radar backscatter signatures. To address the above questions, we are using multi-season ERS-1 SAR data sets of the Bonanza Creek Experimental Forest in Alaska, the Duke Forest and the Michigan Biological Station. Ground truth measurements collected simultaneously with the overflights will be used in conjunction with existing radar models to determine which of the canopy properties are contributing to the backscatter at all wavelengths and polarizations. To date using the airborne Synthetic Aperture Radar (SAR), freeze-thaw conditions have been obtained in Alaska, spring and summer conditions have been obtained over Duke, and a winter-spring data set has been acquired over Michigan with plans for a summer data set in July 1990. Results of the analysis of these data indicate 0.2 to 7 dB changes may be observed due to changing environmental conditions.

W92-70638 **579-42-01**
Goddard Space Flight Center, Greenbelt, MD.
LAND INFLUENCE ON THE GENERAL CIRCULATION-STUDIES OF THE INFLUENCE OF ANOMALIES IN THE BIOSPHERE ON CLIMATE
Yogesh C. Sud 301-286-7840

The objective of this RTOP is to investigate the influence of land-surface processes on the climate change. Two parallel efforts were made during the transition year 1990. The existing 9-layer model was used to conduct several long integrations to determine the ability of the model to produce observed climate change. The ultimate aim is to superpose vegetation-atmosphere interactions on realistically simulated climate. The second effort required development of a future Earth Observing System (Eos) hydrologic cycle model. This effort is currently in progress and SiB, Arakawa-Schubert cumulus convention and Sud-Molod rain re-evaporation are being included in the model.

W92-70639 **579-42-02**
Goddard Space Flight Center, Greenbelt, MD.
MODELING AND MULTISPECTRAL SATELLITE DATA ANALYSIS FOR LAND SURFACE STUDY WITH SPECIAL EMPHASIS ON HOT ARID AND SEMI-ARID REGIONS
Bhaskar J. Choudhury 301-286-5155
(461-13-01)

The objective of this RTOP is to quantify seasonal and inter-annual variations of surface wetness, temperature, microwave polarization difference and spectral vegetation indices over hot arid and semi-arid regions of northern Africa and southeastern Australia for the period 1979 to 1988 using the Scanning Multichannel Microwave Radiometer (SMMR), the Advanced Very High Resolution Radiometer (AVHRR), the Thematic Mapper (TM), and the Special Sensor Microwave/Imager (SSM/I) data. Radiative transfer and heat balance simulations will be performed to understand this data in terms of land surface prognostic and diagnostic variables. A predictive model for surface wetness will be developed based upon SMMR 6.6 and 37 GHz data and tested over an independent region within the U.S. Southern Great Plains. Then the SMMR data will be used to produce soil moisture maps for northern Africa and southeastern Australia for 1979 to 1987. Radiative transfer and heat balance models will be used with hourly meteorologic data acquired from the National Climate Center to simulate reflectances, vegetation indices and surface temperature. The simulated relations between the multispectral data will be compared with the observed relations to evaluate the relative sensitivity to varied surface and environmental characteristics.

W92-70640 **579-42-03**
Goddard Space Flight Center, Greenbelt, MD.
TOPOGRAPHY FROM SEASAT AND GEOSAT OVERLAND ALTIMETRY
Herbert Frey 301-286-5450

The objectives of this RTOP are as follows: to determine the accuracy and quality of topographic data that can be derived from the Specialized Experimental Applications Satellite (SEASAT) and the Geodetic Satellite (GEOSAT) overland altimetry on a global basis; to develop techniques to selectively combine data from SEASAT and GEOSAT overland altimetry; and to demonstrate utility of satellite-derived topographic data for both geological and geophysical problems. The approach will be to: retrack selected portions of the GEOSAT overland altimetry data and merge this with the data already produced by us from the SEASAT mission; produce selected regional maps of combined GEOSAT and SEASAT-derived topography for use in geological and geophysical studies; evaluate the accuracy of these by detailed comparison of the profile data with existing high quality topographic contour maps produced locally for each continent; produce contour maps derived from the satellite altimetry for each continent along with maps showing the quality of the mean values derived for each grid point; and assess the utility of the satellite-derived data for regional geophysical problems such as the mechanism of compensation of the Himalayas and other large continental structures, and for geological problems such as the difference between ancient and modern stream gradients in the Trans-African Drainage System region, the temporal change in water level in the Amazon River and in ephemeral lakes, and the uplift of shorelines due to post-glacial rebound.

W92-70641 **579-42-04**
Goddard Space Flight Center, Greenbelt, MD.
FIS/PLDS MIGRATION
Blanche Meeson 301-286-9282

One of the objectives of this activity is to provide the land science community with a distributed data system to support their research. This data system, the Pilot Land Data System (PLDS), provides several services including an on-line information system (locate and acquire data, access remote computer facilities including data processing facilities), support for science projects, detailed assistance with preparation and publication of data sets on Compact Disk-Read Only Memory (CD-ROM), assistance in the preparation of data sets (e.g., use of standards and documentation) for general distribution, a facility for browsing analog data, and assistance with the collection of LANDSAT data. In FY-92 we plan to pursue this objective by adding significantly to the data described in the PLDS inventories, by providing more thorough documentation, by assisting data producers with the preparation and publication of their data sets, by participating in the information system planning activities for the BOREAS science project and by continuing the coordination and integration of these services at the three PLDS sites.

W92-70642 **579-42-05**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
PILOT LAND DATA OPERATIONS (PLDS)
E. D. Paylor, II 818-354-2867

The Pilot Land Data System (PLDS) is a prototype state-of-the-art data and information system to support research in the land related sciences. It is a multi-NASA center activity led by GSFC and currently comprised of three nodes, one at Ames Research Center (ARC), Goddard Space Flight Center (GSFC), and JPL. The capability is general, inter-center, and based to the extent possible on existing technology. This task will assist in the operation of JPL's node of the PLDS which is responsible for managing land science data resident at JPL. We will: (1) continue to support the PLDS teams for maintaining the overall PLDS system; and (2) continue liaison with, and specifically ensure that the PLDS is responsive to the needs of scientists associated with Code SE of NASA and JPL. JPL personnel will participate in the PLDS Operations and Sciences teams. Liaison and coordination with other ongoing projects, such as the Airborne Visible and Infrared Imaging Spectrometer (AVIRIS) data processing, Synthetic Aperture Radar (SAR) Data Catalog System, Thermal Infrared Mapping Spectrometer (TIMS) data processing, Earth Observing System Data Information System (EosDIS), National Ocean Data System (NODS), and Planetary Data System (PDS), and in particular, the Office of Space Science Information (OSSI) scientific projects will be maintained. JPL participation in PLDS project follows the PLDS project structure established by PLDS Project Management at GSFC. The Phase 1 PLDS has been developed in a way which provided early capabilities to the PLDS science team and Science Working Group, while providing generic capabilities and techniques having a broader use. Phase 1 limited-scale operations were established for the Science Working Group only in early FY-91. Full Phase 2 operations of PLDS began in late FY-91 and will continue this fiscal year.

W92-70643 **579-42-10**
Goddard Space Flight Center, Greenbelt, MD.
AFRICAN CLIMATE AND VEGETATION
Compton J. Tucker 301-286-7122

The objective of this RTOP is to develop the techniques and scientific basis for studying the relationship of precipitation and energy balance to vegetation dynamics as sensed by meteorological satellites for different climatic regions of Africa. Daily NOAA AVHRR satellite data will be processed for Africa and formed into 10-day composite normalized difference vegetation index images with a 7.6 km grid cell size. These data will be stratified by climatic region and related to precipitation and surface energy balance. This will be done for each year from 1982 to 1990.

W92-70644 **579-43-01**
Goddard Inst. for Space Studies, New York, NY.
GLOBAL MODELING OF ATMOSPHERIC METHANE AND ITS ISOTOPIC COMPOSITION
Inez Fung 212-678-5590
(148-90-00)

The objective of this study is to derive a refined budget of atmospheric methane consistent with the observations of methane and its isotopic composition in the atmosphere. With the refined budget will be a first global characterization of the geographic distribution of each of the methane sources and their emissions. The results will identify the measurement locations and strategies necessary to improve the understanding of the sources and sinks.

The major tool will be the global 3-D tracer model developed at Goddard Institute for Space Science (GISS). The model will use, as inputs, global geographic distributions of methane source scenarios which synthesize all available information on their locations and field measurements of their emission characteristics. The modeled global 3-D distributions of atmospheric methane will be compared with the full suite of observations of methane and its isotopes in the atmosphere. The optimal methane budget will comprise the combination of source/sink scenarios which produce the best fit between the observed and modeled distributions.

W92-70645 **579-97-00**
Ames Research Center, Moffett Field, CA.
GLOBAL CHANGE
J. G. Lawless 415-604-5900

The objective of this work is to provide general support for Ames Research Center (ARC) participation in NASA's Mission to Planet Earth Component of the Nation's Global Change Program. This RTOP will be used to provide for support for planning a collaborative consortium of public and private institutions and agencies in California and the West. The approach will be to provide support for drafting planning documents and workshops as necessary to define the science objectives for the proposed consortium and to develop an administrative and operations plan. In addition, the interface to efforts proposed by the Aspen Global Change Institute will be developed.

W92-70646 **579-97-02**
Goddard Space Flight Center, Greenbelt, MD.
TROPICAL DEFORESTATION, ISY
Compton J. Tucker 301-286-7122

Tropical deforestation is occurring at a rapid and accelerating rate. While this is accepted as fact for specific areas, there is extreme controversy over the extent and rate of tropical deforestation at country, continental, and global scales. Unless controlled, tropical deforestation will result in the loss of over half of the planet's plant and animal species and will significantly elevate atmospheric concentrations of CO2, CH4, and CO. An expanded, comprehensive, and bi-lateral Brazilian-American study of the deforestation and habitat fragmentation for the entire Amazon Basin of South America will be produced using LANDSAT Thematic Mapper Satellite data coupled with a series of field verifications in Brazil. In the first year we will produce deforestation and habitat fragmentation figures for the entire Amazon Basin of South America for 1988, in the 2nd year we will produce similar results for 1984; and in the 3rd year we will produce similar results for 1991.

W92-70647 **579-98-00**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
COSPAR MEETING - GROUND TEMPERATURE
A. B. Kahle 818-354-7265

The objective is to organize and conduct a two-day Scientific Meeting at the COSPAR meeting to be held in Washington, D.C., August 1992. The number and title for this meeting is A8 - Remote Sensing Methods and Challenges in Estimating Surface Temperature from Spacecraft, Aircraft and Ground-based Platforms. The objective of this meeting is to review the recent developments in remote monitoring of surface temperatures, which will play an important role in future global change studies. Deriving accurate surface temperatures from remotely sensed measurements is not straight forward for land surfaces, because emitted radiance is a function of both the (unknown) spectral emissivity and the surface kinetic temperature. Also complicating the concept are surface heterogenity, roughness at all scales, shadowing, and atmospheric effects. Various techniques to derive surface temperature from existing and future remote sensing systems such as EOS will be discussed, compared and evaluated.

Data Systems

W92-70648 **656-50-05**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
INFORMATION SYSTEMS NEWSLETTER
S. L. Dueck 818-354-5073

The purpose of the Information Systems Newsletter is to inform the Space Science and Applications Research and Science community about Information Systems development and to promote coordination and collaboration between NASA offices and NASA centers by providing a forum for communication on a quarterly basis. The Information Systems Newsletter is produced quarterly and focuses on programs sponsored by the Information Systems Office in support of the Office of Space Science and Applications and includes articles of interest from other programs and agencies. Collaborative and coordinated Information Systems Office programs are encouraged by developing mechanisms and plans for coordination at specific Information Systems meetings and at related workshops, conferences, and meetings. Technical and policy review are provided by JPL's Office of Space Science and Instruments by NASA Headquarters.

W92-70649 **656-61-02**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
DATA SYSTEM INTEGRATION (COMMONALITY AND INTEROPERABILITY)
L. E. Preheim 818-354-5041
(656-61-03)

The primary purpose of the Data System Integration Task is to provide proof of concept: system building blocks can and should be identified, packaged and reused on a regular basis. A building block is the embodiment of a functional capability. It may be: (1) a hundred lines of generic C code implementing an optimal algorithm in a hardware independent fashion; (2) several thousand lines of code which could be adapted to an operating environment (e.g., VMS or UNIX); (3) a complete stand-alone subsystem (a turn-key data capture facility with a NASCOM interface built in; (4) firmware in a chip; or (5) a subroutine library. In short, a building block is an existing solution to a well understood data system need. Reusable system building blocks are seen as a key element in data system interoperability. Promoting interoperability is a second thrust for this task. The key to fostering use/reuse of building blocks is to show the benefit of each in an environment which is operational, similar to the users' and demonstrates portability and maturity of the block. A further necessity is to have in place an infrastructure for support (problem reporting, update notification, installation support, etc.) The task is organized into five complementary activities: (1) identify functions which are common to existing or planned OSSA data systems; (2) produce a generic system reference model which supports both the common functions and the data system unique functions; (3) identify and promote the development of standards necessary to support the reference model; (4) identify and provide a set of common building block software components which instantiate the high payback common functions of the reference model; and (5) provide a plan by which new and expanding data systems can draw upon common building blocks and thus evolve toward the common architecture and interoperability within the 1995 time frame.

W92-70650 **656-61-03**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
DATA INTERCHANGE STANDARDS
J. Grimes 818-354-3890
(656-61-02; 656-61-05; 656-61-06)

The purpose of this RTOP is to develop standard methods for organizing (grouping) and identifying information with the long-range objective of facilitating automated, generic services. An associated task, the Control Authority, registers identifiers for formats and data description languages, preserving and disseminating these definitions. This helps contemporary or future users of the data to have recourse to the definitions even if they

were not necessarily the ones who generated the data. The work is based on the Standard Formatted Data Unit (SFDU) Concept, a technique under development by NASA in cooperation with 22 other space agencies of the world who are part of the Consultative Committee for Space Data Systems (CCSDS). In addition, it focusses on (1) understanding the SFDU System environment and architecture at JPL; and (2) the development of standard software tools to provide services for users working with SFDUs and other activities directly in support of projects at JPL; and (3) development of a prototype compiler to be used with Transfer Syntax Description Notation (TSDN), a language developed under this program with unique capabilities that address the particular needs of data format descriptions. The effort is divided into the following major areas: (1) SFDU System Engineering: Complete the SFDU system arhitecture for the JPL environment; Generate Phase 2 ToolSet Functional Requirements Document; Improve user support and user feedback to SFDU developers (e.g., application engineering support for first-time implementors of the SFDU concept such as MO, MGN, TOPEX, NAIF, PDS, etc.); (2) continue the development of standard portable S/W tools for creating, manipulating, displaying and managing SFDU products; and (3) develop Transfer Syntax Description Notation (TSDN) prototype compiler as a first step in developing tools for users to describe and interpret their data sets at the Fundamental Support Level.

W92-70651 **656-61-05**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
NAVIGATION ANCILLARY INFORMATION FACILITY (NAIF)
C. H. Acton 818-354-3869
(155-20-00)

This RTOP develops and tests prototype software and data management technology, collectively called the SPICE system, that is used to facilitate the preparation, archiving, distribution and user access to navigation and related ancillary geometry information required to obtain a full understanding of the science data returned from space-borne instruments. Accommodation is made for requirements that pertain to planning such observations, and for assisting with engineering aspects of mission operations. The work is conducted in direct response to recommendations of the National Academy of Science's Committee on Data Management and Computation. It is particularly relevant as instrument complexity, instrument data volume and interest in correlative analyses grow. The work supports the objectives of reduced mission cost using remote telescience concepts. The NAIF development approach follows recommendations to keep the space science community involved in all stages of SPICE development, and to provide prototype component capabilities to scientists for evaluation in conjunction with ongoing research. In addition, with a major role in supporting flight project operations, NAIF must ensure that its SPICE standards and methodology are consistently applied across active mission and post-mission time frames.

W92-70652 **656-61-06**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
PDS: DATA DISTRIBUTION AND ARCHIVE TECHNOLOGY
S. K. McMahon 818-354-8127
(155-20-01)

The overall objective of this RTOP is to improve data distribution plus archive technology and methods for science data systems. It uses the Planetary Data System as the initial test-bed, but the technology and methods developed are applicable to data systems of all disciplines. There are three parts to this RTOP, labeled as A, B, and C. The objectives of Part A are to develop and implement a Data Distribution and Archive Lab at JPL. This facility will provide assistance to the PDS and other NASA programs in distributing new or existing data sets on CD-ROM disks; will develop or adapt a basic set of software tools for preparing and accessing data sets distributed on CD-ROM; continue to develop the Distributable Data System Concept, where CD-ROMs contain full sets of documentation, catalog, geometry, software and data; and will evaluate optical and magnetic data storage media for both data distribution and data systems. As a complement to the technology enhancement objectives, an equally important objective, Part B, is to improve the methods of how OSSA plans for and actually transfers mission archive data into long term archives, especially attacking the problems posed by: (1) very large data volumes; and (2) transfers from the flight projects with distributed data systems. Current OSSA plans are to produce hundreds, even thousands, of CD-ROMs in the next few years. Part C, the third task, will prototype techniques for storing hundreds of such CD-ROMs while providing rapid access for science users over networks. Such systems could be helpful to OSSA archive systems as well as many educational institutions. The approach used for Part A will be to coordinate with and support archiving efforts of other data systems (NSSDC, NODS, MIPL, FIST, SAR, etc.) to avoid duplication of effort. All tools will be developed to run on off-the-shelf computers to allow wide distribution and utilization by the science community. The approach for Part B will be to plan and prototype large volume and electronic science/catalog transfer techniques using current standards and actual flight project data and teams. Lessons learned from the prototyping on risk avoidance and cost reduction will be passed on to other discipline archive systems. The approach used for Part C will be to test the capability of a jukebox file-server plus networks for CD-ROM archiving and rapid access.

W92-70653 **([L) 656-61**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
SCIENCE DIGITAL DATA PRESERVATION
S. LaVoie 818-354-5677

The objectives of the RTOP are: inventory and evaluate all tapes (135,000); preserve valuable data and make the data more accessible to the user; reduce the volume of tapes by converting to a higher density media and disposing of duplicate data; and transfer converted tapes and archive responsibility to the Planetary Data System or the National Space Science Data Center (NSSDC). The approaches are: (1) Phase 1 - Inventory and Evaluation (Recall all tapes. Organize, inventory and catalog tapes. Evaluate tape value under guidance of Science Data Evaluation Board (representatives from science and technical community knowledgeable about the data). Prepare valuable data for conversion, distribute or dispose of duplicate data. Publish Phase 1 report). Evaluate conversion alternatives for both archive media and hardware/software approach (in preparation for Phase 2). Publish Draft Conversion Plan and Schedule); and (2) Phase 2 - Conversion (Convert all valuable data to high density media. Generate catalog of tape contents. Transfer tapes and archive responsibility to Planetary Data System or NSSDC. Publish task final report.)

W92-70654 **656-61-13**
Goddard Space Flight Center, Greenbelt, MD.
SS FREEDOM ARCHIVE PLANNING STUDY
Joseph H. King 301-286-7355

This RTOP supports a study of the requirements to be satisfied by NASA, and in particular by NASA/SMI and its principal agent, NSSDC, in the permanent archiving of data from the spaceflight missions of the Life Sciences and Microgravity Divisions. As a concluding part of this study, a Lessons Learned Document (LLD) is being developed summarizing the experiences of previously developed DDS's, so as to avoid needless repetition of previous mistakes.

W92-70655 **656-61-17**
Goddard Space Flight Center, Greenbelt, MD.
NSSDC ASTROPHYSICS DATA SYSTEMS SUPPORT
Michael E. VanSteenberg 301-286-7876
(399-30-00)

The purpose of this project is the continued development and utilization of technologies that help the National Space Science Data Center (NSSDC) support the Astrophysics Data System (ADS) effort. The scope of this RTOP is divided into three parts: (1) Generic On-Line Data Access/Distribution Tools (in this facet we plan on providing generic software tools that will enable the general scientist to stage or promote data from near- and/or off-line status to on-line status, examine or browse data that has been staged,

and extract or subset data for distribution; (2) Generic On-Line Documentation/Literature Tools (in this facet we plan to develop generic software tools that will support digitization of textual data and pertinent documentation/literature, maintenance and storage of digitized textual data, formatting and media preparation for distribution of textual data, distribution of textual data and documentation by request, and provision of on-line access to pertinent TBD textual data); (3) Application of Generic Tools as ADS Services. In this facet we will install the tools developed in the above. In particular, we will establish services at the NSSDC ADS node which include on-line catalogue/data staging, browsing, and extraction as well as on-line access to sets of Astrophysics journal literature.

W92-70656 **656-61-18**
Goddard Space Flight Center, Greenbelt, MD.
SPACE PHYSICS DATA SYSTEM
Robert E. McGuire 301-286-7794

A primary goal of NASA space science missions is the collection and analysis of scientific data. Recent experience in the NASA science community strongly argues that a discipline-oriented data system can significantly enhance the ability to both adequately archive and effectively access the most valuable of these data products. Such a discipline-oriented data system has not been previously defined or implemented for the support of the disciplines within the Space Physics Division. This multi-year RTOP is intended to be the vehicle by which the definition, design and initial implementation of a new Space Physics Data System (SPDS) can be accomplished. Direction of the effort will be by the SPDS Steering Committee (SPDS/SC) appointed by NASA Headquarters. Elements of the plan include: (1) support for the initial definition of scope and priorities of the SPDS, including preparation of background materials on relevant existing and planned data systems and preparation of strawman scenarios for the scope and initial approach to the SPDS effort; (2) support for initial SPDS data set assessment and prioritization efforts; (3) direct support for an accelerated space physics data restoration and directory population at NSSDC itself; and (4) design/implementation of appropriate subsystem elements of SPDS.

W92-70657 **656-61-20**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
PLANETARY HARDCOPY PRESERVATION
L. J. Pieri 818-354-8320
(656-61-07)

Planetary flight project data exists in a variety of media including hardcopy products; film, printer paper, computer listings, drawings, photographic paper, plots, etc. Much of these data are produced during the active mission phases, but are valuable in a post-mission analysis phase. It is important to ensure the preservation of these products for long-term science community access. This RTOP addresses the need for the proper identification, evaluation, disposition, recommendations, handling and storage techniques, reproduction and/or appropriate media conversion for these products. An objective is to ensure preservation of valuable hardcopy planetary data for use by the planetary science community by examining and assessing planetary hardcopy data products contained within the Voyager Imaging Library and Regional Planetary Image Facility collections; coordinate with the PDS and/or the Digital Data Preservation activity to establish products which should be disposed of, adequately stored in the current media for long term preservation, converted to a different media or reproduced/restored; recommend, based on research and coordination with other institutions concerned with the preservation of hardcopy products, adequate storage techniques or conversion techniques; ultimately ensure product life through media conversion, adequate storage methods or reproduction. The first year deliverables would focus on the developing policies and procedures for disposition, performing product assessment, producing inventories, and making recommendations for approval on the disposition of the products and sizing the next year activities. The second and third year activities include: producing a plan for the implementation of adequate storage techniques, reproduction and/or media conversion methods. Specific deliverables for this year include: (1) generate policies and procedures in coordination with the Science Data Evaluation Board, for hardcopy product assessment/handling/disposition, publish document; (2) perform Voyager Imaging Library and RPIF collection assessment, dispose of non-valuable products, perform detailed inventory; (3) make recommendations, for approval, to either PDS Discipline Nodes and/or SDEB for disposing products, ensuring adequate storage for those retained, for media conversion for those that would benefit from media conversion, or reproducing the products; and (4) size second and third year activities for implementing storage techniques, conversion or reproduction activities.

W92-70658 **656-65-03**
Goddard Space Flight Center, Greenbelt, MD.
GENERIC VISUALIZATION OF SCIENTIFIC DATA
Gregory W. Goucher 301-286-2341

The objective of this research is to develop a data visualization system for non-programmers to help support correlative data display and analysis for NASA-sponsored research in the space and earth sciences. Such a system is the NSSDC Graphics System (NGS), which is operational in the DEC VAX/VMS environment and forms a core capability for a variety of applications. In FY-92 the strategy is to continue to expand this operational system to include new visualization techniques and implementations in heterogeneous (UNIX, etc.) environments. Furthermore, new spatial data structures, such as the sphere Quad-trees, will be studied and applied to the data management aspect of complex data sets. The tools will be made available to the maximum extent possible for correlative data visualization and analysis. The NGS currently supports the NSSDC's Network Assisted Coordinated Science (NACS) system in support of the Coordinated Data Analysis Workshop (CDAW) and the NASA Climate Data System (NCDS) as well as individual NASA/GSFC scientists.

W92-70659 **656-65-04**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
IMAGE ANIMATION LABORATORY FOR SCIENCE VISUALIZATION
K. J. Hussey 818-354-4016
(656-65-06; 656-65-05)

This task will develop the visualization technology to allow integration of scientific data from several disciplines for the analysis of multi-dimensional images, including animations at the highest useful spatial resolution. The purpose of this is to assist scientists in their research: Earth Scientists, Planetologists and Astrophysicists must think in several dimensions to solve many of their problems, yet most data are represented in 2 dimensions. Interactive tools will be developed in a workstation environment to properly combine and then visualize multidisciplinary data in several dimensions. These tools will include volume visualization and analysis, two and three dimensional animation and analysis, metadata visualization and morphometric feature extraction. Attention will be given to the generalization of techniques so that similar three dimensional models may be constructed from comparable data sets. This work will be done in close cooperation with scientists whose data is being visualized. The approaches are: (1) use a task team - consisting of the scientists whose data is to be visualized and a programmer - to further visualization capabilities in a manner consistent with achievable technology and scientific utility; and (2) design and implement the software for portability and extensibility (i.e., generic X-windows implementations) using commercially available general purpose computing platforms (Sun 4's). This includes a scientist friendly user interface. Additional data structures will be coregistered by extending existing techniques and development of new ones. We will generalize the methods, techniques and tools developed in previous FY's to handle a broad range of scientific data and deliver these tools to scientists for feedback. Due to the true 3D nature of scientific data, the use of volumetric data visualization techniques will be incorporated.

W92-70660 **656-65-05**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
GRAPHICAL METHODS FOR SCIENCE VISUALIZATION AND DATA ANALYSIS
A. S. Jacobson 818-354-0693
(656-65-23)

The long-term objective of this task is to apply computer graphics technologies and methods to enable the display, manipulation and analysis of large datasets. The development of computers with the power of calculate models of ever-increasing complexity, and remote sensors with very high spatial, spectral and temporal resolutions, threaten to swamp scientists with data. The contribution of computer graphics is that it brings the unique pattern recognition capabilities of the human eye/brain system to bear on this flood of data. The near-term objective is to provide a set of tools which permit the scientist to graphically display and interpret multidimensional, multivariate data, either alone or in collaboration. The system must permit quantitative as well as qualitative analysis. The approach taken here is to design and implement a computing and display environment, using off-the-shelf hardware combined with specially developed software, which enables simultaneous interaction with (and linked display of) multiple large complex datasets. The current product is called Linked Windows Interactive Data System (LINKWINDS). It will permit a user to interact with multiple software applications under his/her control. The applications and their data can be manipulated in a series of co-varying windows for the study of trends, variations, anomalies, and correlations. The development process will be iterative. Applications are to be prototyped rapidly in the LINKWINDS environment and applied to specific data analysis tasks by users. The results are then fed back for the next stage of development. The system will eventually contain tools for allowing users to create their own applications.

W92-70661 **656-65-06**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
SOLAR SYSTEM VISUALIZATION (SSV): SCIENTIFIC TOOLS FOR NASA/JPL IMAGE ARCHIVES
E. M. DeJong 818-354-0302
(656-65-04; 656-61-07; 656-74-03; 196-41-71)

The objectives are to: (1) create a realtime, interactive, scientific visualization environment which allows scientists to personally control all aspects of visualization, analysis, and data assimilation processes (the goal is realtime interactive visual comparison of data with scientific models); (2) develop a prototype high performance science analysis workstation and an inexpensive previewing image animation workstation. Existing tools will be adapted and new scientific tools for use with the NASA/JPL solar system exploration archive will be developed. The workstations will be testbeds for evaluating and comparing new computer algorithms and architectures; (3) create planetary science Image Data Sets (IDS), and scientific visualization and analysis problems. The image data sets and problems would serve as benchmarks. They would be used to compare and evaluate new visualization and analysis algorithms/systems, and as educational material. They will be stored on CD-ROM for inexpensive distribution; and (4) integrate and test these tools and provide a quantitative assessment of the achievement of the first three objectives. Scientific tools, image data sets and benchmark programs will be developed to meet the needs of the planetary science community, as reflected by current flight projects. The Earth, from a global/planetary perspective, will also be included. The SSV science team will test the effectiveness of the visualization, scientific analysis, and data assimilation tools. Collaborations will be developed with flight projects.

W92-70662 **656-65-07**
Goddard Space Flight Center, Greenbelt, MD.
CENTER FOR EXCELLENCE FOR SPACE DATA INFORMATION SCIENCES (CESDIS)
Jan M. Hollis 301-286-7591

The objective is to operate at GSFC a Center of Excellence for Space Data and Information Sciences (CESDIS) which will consist of a consortium of university, industry, and government scientists engaged in computer science research addressing NASA's long-term space and Earth sciences data and computational problems. This RTOP will support a contract with the Universities Space Research Association (USRA) to administer, coordinate, and manage the award of grants to participating universities: to negotiate appointments of industrial and government associates to CESDIS; to conduct periodic peer reviews of CESDIS by the USRA Council; and to act as the interface between NASA and CESDIS.

W92-70663 **656-65-21**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
KNOWLEDGE-BASED ASSISTANCE FOR SCIENCE VISUALIZATION AND ANALYSIS USING LARGE DISTRIBUTED DATABASES
T. Handley 818-354-7009
(656-65-23)

This RTOP addresses four areas of significant need: scientific visualization and analysis; science data management; interactions in a distributed, heterogeneous environment; and knowledge-based assistance for these functions. The fundamental innovation embedded within this RTOP is the integration of three automation technologies, viz knowledge-based expert systems, science visualization and science data management. This integration is based on a concept called the DataHub. With the DataHub, NASA will be able to apply a more complete solution to all nodes of a distributed system. Both computational nodes and interactive nodes will be able to effectively and efficiently use the data services (access, retrieval, update, etc.) in a distributed, interdisciplinary information system in a uniform and standard way. This will allow the science investigators to concentrate on their scientific endeavors, rather than to involve themselves in the intricate technical details of the systems and tools required to accomplish their work. Thus, science investigators need not be programmers. The emphasis will be on the definition and prototyping of system elements with sufficient detail to enable data analysis and interpretation leading to publishable scientific results. In addition, the proposed work includes all the required end-to-end components and interfaces to demonstrate the complete concept.

W92-70664 **656-65-22**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
GEOGRAPHICAL INFORMATION SYSTEM FOR FUSION AND ANALYSIS OF HIGH-RESOLUTION REMOTE SENSING AND GROUND TRUTH DATA
A. Freeman 818-354-1887

We seek to combine high-resolution remote sensing data with ground truth measurements and radar image models in the context of a Geographical Information System. The GIS database will be integrated with an existing set of image/data analysis tools and visualization techniques. Then via case studies of two forest sites, one boreal and one tropical, we will investigate the correlation between ground truth, e.g., biomass and vegetation water content, and the remotely sensed data, explore the optimum combinations of remotely sensed data to study various aspects of forest ecology, e.g., change with temperature, different species and the effects of rainfall. The data set and software tools will also be used to validate the radar models, which are based on ground data measurements. We will make use of a unique set of calibrated SAR data at two forest sites, together with ground data maps and data from optical/IR sensors. This data will be incorporated into a JPL-developed GIS database, termed VICAR/IBIS. We will use the software at our disposal to geocode the radar data, classify, analyze and visualize it, correlate it with data from other sources, and model the radar backscatter response to changes in key biogeophysical parameters. Existing image processing software will be integrated into the GIS in a toolkit format, which can be easily extended for additional applications.

W92-70665 **656-65-23**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
A DISTRIBUTED SYSTEM FOR VISUALIZING AND ANALYZING MULTIVARIATE AND MULTIDISCIPLINARY DATA
A. S. Jacobson 818-354-0693
(656-65-05)

The objective of this program is to apply the Linked Windows Interactive Data System (LinkWinds) in a complex environment containing many of the elements addressed by scientists working in multidisciplinary teams on very large and distributed data bases. The specific objectives of the proposed three-year program are: (1) develop visual data analysis tools and controls specific to at least two science disciplines, and demonstrate them in current research efforts; (2) adapt LinkWinds to X-Windows for execution in a network environment on different workstations, and demonstrate its ability to display and analyze data sets residing in several distributed data storage locations and computationally supported by remote computing facilities; (3) use the adapted LinkWinds to demonstrate cooperative and interactive televisualization and analysis of data by geographically separated science teams. The atmospheric science goal is to develop effective tools for the comprehensive analysis of Nimbus 7 data and anticipate needs of the UARS and EOS missions. The Nimbus 7 data sets have been chosen because they consist of several levels of data products analogous to the planned data structure for upcoming missions. The geologic science goal is for comprehensive analysis of high-dimensional image data sets analogous to those to be delivered by EOS instruments. Current geologic studies utilize data from aircraft instruments (AVIRIS, TIMS) which prototype data sets to be available from HIRIS and TIGER. This is collaboration between the JPL Earth and Space Sciences Division, which will develop the data analysis tools and carry out original research using the tools; the San Diego Supercomputer Center, which will contribute to the development and jointly conduct experiments in computation and analysis over high-speed networks; and Silicon Graphics, Inc. which will contribute graphics workstations to the effort.

W92-70666 **656-65-24**
Ames Research Center, Moffett Field, CA.
CONSTRUCTION OF AN ADVANCED SOFTWARE TOOL FOR PLANETARY ATMOSPHERIC MODELING
H. Lum 415-604-6544
(595-12-22)

The construction of scientific software models is an integral part of doing science, both within NASA and within the scientific community at large. Typically, model-building is a time-intensive and painstaking process, involving the development of very large, complex computer programs. Despite the considerable expenditure of resources involved, completed scientific models cannot easily be distributed and shared with the larger scientific community due to the complex, idiosyncratic nature of the implemented code. To address this problem, this research proposes constructing a software tool called the Scientific Modeling Assistant that serves as an aid to the scientist in developing, using, and sharing models. To facilitate model-building, we propose building a software system that incorporates an interactive intelligent graphical interface, a high-level domain-specific modeling language, a library of physics equations and experimental datasets, and a suite of data display facilities. Rather than construct models using a conventional programming language, scientists will use our graphical interface to program visually using a more natural high-level data flow modeling language. In constructing this tool, we will use a variety of advanced software techniques, including artificial intelligence techniques, as well as techniques from object-oriented programming, graphical interfaces, and visualization. To test this approach, we will build a software prototype in the domain of planetary atmospheric modeling.

W92-70667 **656-65-25**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
MULTI-CHANNEL HOLOGRAPHIC BIFURCATIVE NEURAL NETWORK SYSTEM
Hua-Kuang Liu 818-354-8935

The overall objective of this RTOP is to produce an optical adaptive resonant system (OARS). To achieve the objective, the work is divided into three phases. During the first phase, the underlying behavior of the OARS including the data throughput capacity, cross-correlation interference, fault tolerance, and signal-to-noise ratio properties are studied via theoretical analysis and experimental test. The objective of the Phase 2 work is to investigate hardware implementation for breadboard demonstration. The third phase objective is to see how the system can be used for EOS data analysis and other applications. The approach to achieve the RTOP objective includes the state-of-the-art techniques of free-space holographic interconnection and optical parallel processing capabilities with multi-channel input capacity. The multi-channel input is realizable by holographic optical elements (HOE) and high speed updatable Spatial Light Modulators (SLM's). Photorefractive crystals will be used for the formation of the bifurcative decision-making process. The OARS has a brain-like nature. In the implementation of an OARS, we store the a priori known objects in photorefractive crystals in holographic grating form with the unique features of artificial plasticity for self-programming capability. Then any new input can be compared at high speed with the stored images for recognition and classification.

W92-70668 **656-65-26**
Goddard Space Flight Center, Greenbelt, MD.
A SPATIAL ANALYSIS AND MODELING SYSTEM FOR ENVIRONMENTAL MANAGEMENT
Fran L. Stetina 301-286-5717

This is a proposal to develop a uniform global environmental data gathering and distribution system to support the calibration and validation of remotely sensed data. SAMS is based on an enhanced version of FEMA's Integrated Emergency Management Information System and DoD's Air Land Battlefield Environmental Software Systems. The approaches are to: (1) develop system integration and software development plan; (2) initiate flood plan forecast and hydrological applications model selection; and (3) begin evaluation of image processing software, GIS software and system integration software.

W92-70669 **656-74-03**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
CONCURRENT PROCESSING TESTBED - SCIENCE ANALYSIS
J. E. Solomon 818-354-2722
(656-65-04; 656-65-05; 656-65-06)

The major objective of this task is the extension of concurrent processing testbed technology to an integrated science analysis environment. In the context of the National High Performance Computing and Communications (HPCC) Program, this includes providing a transitional environment between modest performance (100's MFLOPS) concurrent systems and systems capable of giga-/tera-flop performance. The three major elements of this objective are: (1) development and demonstration of integrated science analysis and visualization tools; (2) development and demonstration of a data/information management system for a distributed/concurrent computing environment; and (3) development of techniques and utilities for heterogeneous distributed computing resources to support computationally intensive science analysis activities. The approach to meeting these RTOP objectives draws heavily on the experience gained over the past two years in development and implementation of the concurrent processing testbed and its software environment, the Concurrent Image Processing Executive (CIPE). In addition, the experience and insight gained in applying this technology to real-time science information extraction during the recent Voyager Neptune encounter will be applied to the development of a science analysis testbed capable of handling the volume and complexity of data represented by both EOS and future planetary exploration

mission instrumentation. Focus for development and demonstration of science analysis capabilities in a distributed computing environment will be provided by specific problems in planetary atmospheric dynamics analysis and visualization. This problem domain provides a full range of relevant challenges for integration of data management, analysis, and visualization utilizing concurrent computation technology. The transitional problem, i.e., the problem which requires bridging the gap between modest- and truly high performance machines, is that of algorithm and software development for merging dynamic atmospheric model calculations with time-dependent image data observations.

Search and Rescue Mission

W92-70670 **669-30-01**
Goddard Space Flight Center, Greenbelt, MD.
SEARCH AND RESCUE ADVANCED TECHNIQUES
W. A. Hembree 301-286-8332

The purpose of this RTOP is to apply aerospace technology to the support of the search and rescue community, beyond the now-operational COSPAS-SARSAT system, in particular to enhance the future effectiveness and scope of the COSPAS-SARSAT system; to demonstrate the application of aerospace instruments to remote area searches without emergency beacons; to explore and develop methods for optimum use of emergency beacon data from geosynchronous satellites; and to apply aerospace technology to disaster mitigation. Other goals are to develop improved receiver-processor techniques with decreased susceptibility to interference, demonstrating improved emergency beacon performance; begin development of a demonstration system to determine scope of applicability of the technique, continuing optimization of radar data analysis for crash detection; demonstrate use of emergency beacons incorporating the Global Positioning System for self-location, exploring methods for combining data from low- and geosynchronous-orbiting satellites for enhanced beacon detection and location; and support NASA efforts in demonstration of disaster mitigation techniques and systems.

Space Processing Science and Spacelab Payload Development

W92-70671 **674-21-05**
Lewis Research Center, Cleveland, OH.
ELECTRONIC MATERIALS
Jack Salzman 216-433-2868
(694-24-00; 694-03-03; 694-22-00; 694-23-00)

The plan for this task is to continue an in-house cooperative project with Westinghouse Research Laboratories and to manage a contract with Westinghouse to study the growth kinetics of physical vapor transport processes. The objectives of this project include achieving a quantitative understanding of crystal growth processes, identifying convective effects, and obtaining optimal process control parameters for desired crystal structure and properties. We concentrate on physical vapor deposition and Bridgman growth and typically use high temperature transparent furnaces to allow observation of growth of technologically significant materials.

W92-70672 **674-21-06**
Langley Research Center, Hampton, VA.
ELECTRONIC MATERIALS
A. L. Fripp 804-864-1503

The objective of this research area is the ground based development of theory and techniques which will support Microgravity Science flight experiments. The approach is the development of mathematical models and fluid flow measurement techniques which are applicable to Microgravity Science experiments.

W92-70673 **674-21-08**
Marshall Space Flight Center, Huntsville, AL.
ELECTRONIC MATERIALS
S. L. Lehoczky 205-544-7758

In any crystal growth system, an important problem is that the compositional and/or thermal fluctuations in the fluid phases cause compositional inhomogeneities and defects in the growing crystal. Where these fluctuations are caused by convection and sedimentation, they can be reduced in low gravity. Therefore, the major objectives of this crystal growth program are to understand the role of gravity and determine limitations in Earth's gravity, determine and demonstrate advantages to be obtained by growing crystals in space, and apply the findings to help solve problems in the growth of electronic and detector crystalline materials. The types of growth that will be explored in this program include melt, solution, vapor, and float zone growths. Crystal growth by solidification from the melt is the most widely used technique for high technology single crystalline materials. The success of the technique depends on the control of the composition, temperature, and morphology of the solidification interface. Advantages of the solution growth technique include the control it provides over the temperature of growth and viscosity. In the vapor approach, there are two distinct mechanisms for growing a crystal: (1) the physical vapor deposition, and (2) chemical vapor deposition (CVD). Finally, floating zone crystal growth is accomplished by supporting a polycrystalline rod at both ends, melting a portion of it with a moving heater, and growing a crystal behind this zone.

W92-70674 **674-22-05**
Lewis Research Center, Cleveland, OH.
COMBUSTION SCIENCE
Jack Salzman 216-433-2868
(694-24-00; 694-03-03; 694-22-00; 694-23-00)

The objective of the activities covered by this RTOP is to obtain an understanding of the fundamental combustion phenomena for which low gravity analysis and experimentation can be of use in: (1) isolating the gravity-related mechanisms (e.g., buoyant convection); (2) determining the influence of transport phenomena normally obscured by gravitational effects (e.g., thermophoresis, thermocapillarity, simple mass and thermal diffusion); (3) creating desired symmetries and/or boundary and initial conditions (e.g., spherical droplets, negligible sedimentation); and (4) improving in-space system performance, principally spacecraft fire safety.

W92-70675 **674-23-01**
Lyndon B. Johnson Space Center, Houston, TX.
BIOTECHNOLOGY RESEARCH
G. Spaulding 713-483-2357

This research is focused on the development of science in support of the NASA Biotechnology Program. The projects within the RTOP will have five general objectives: to gain a better understanding of basic cell science questions of importance to current biotechnology which have apparent gravity induced limitations or can be better studied in the microgravity environment; to study unique bioprocess limitations caused by gravity dependent phenomena and determine the potential for improvement during biological processing in microgravity; to develop methodology and procedures for accomplishing biotechnology investigations in microgravity; to explore new research applications of biological target materials and new technology innovations; and to define and develop analytical methods and requirements for biotechnology

research facilities planned for the U.S. Space Station. This RTOP is designed to serve as a basic science resource in support of NASA Biotechnology. Research will be performed both in-house at Johnson Space Center (JSC) and at associated universities, research centers, and institutions. JSC will perform independent research and serve as a point of contact for the extramural investigators. JSC will participate in the analysis of results, promote scientific communication, and aid the investigators in the development of NASA relevant research efforts. Scientific data resulting from these studies will be used to formulate new proposals for flight experiments, promote ground-based applications of these technologies, and refine the scientific background and justifications for proposed flight experiments.

W92-70676 **674-23-08**
Marshall Space Flight Center, Huntsville, AL.
BIOTECHNOLOGY
Robert S. Snyder 205-544-7755

The long-range objective is to utilize the environment of space to separate, purify or crystallize, and analyze biological products. The intermediate objectives are to develop the required technology and to expand the base of knowledge involved with processing biologicals in space; to identify, evaluate, and select the most promising processes; and to explore new areas of separation technology. Separation and purification procedures which have been found to produce inadequate results on the ground because of gravity-dependent problems will be investigated. More specifically, this program will determine possible advantages of the low-gravity environment for separation, purification, crystallization, and characterization of biomedical materials; design, develop, manufacture, and test experiment apparatus to conduct experiments in low gravity; apply ground/flight knowledge to the improvement of bioprocessing procedures on Earth; develop broad and strong collaborative interactions with research scientists; and identify and explore new techniques of separation or bioprocessing that might be enhanced by low gravity.

W92-70677 **674-24-04**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
FLUID DYNAMICS AND TRANSPORT PHENOMENA
D. Strayer 818-354-1698

The Fluid Dynamics and Transport Phenomena RTOP consists of two tasks, the Coherence Length Task and the Low Temperature Experiments for Microgravity Task. The Principle objectives of these tasks are discussed. The Coherence Length Task is being carried out by Professor R. Donnelly under a contract to The University of Oregon. The objective is to study finite size effects in a thermodynamic quantity that is diverging near a critical point. In particular, it is intended to measure the expansion coefficient of liquid helium both below and above the lambda transition in a well characterized geometry. This data should provide a stringent test for renormalization group theory, especially regarding proper boundary conditions. The Low Temperature Experiments for Microgravity Tasks is an overguideline task that will be performed at JPL by Resident Research Associates (RRA) of the National Research Council. The principle objective of this task is to begin the development of ideas for low temperature research in the microgravity environment of space. Specific objectives are to perform measurements of the attenuation of third sound in superfluid helium films to demonstrate the potential for applying third sound to microgravity measurements; to design a low temperature apparatus to levitate and control a drop of liquid helium so the superfluid can be studied isolated from all solid boundaries; and to develop a gravity-compensated sample chamber by applying electric field gradients to a liquid helium sample.

W92-70678 **674-24-05**
Lewis Research Center, Cleveland, OH.
FLUID DYNAMICS AND TRANSPORT PHENOMENA
Jack Salzman 216-433-2868
(694-24-00; 694-03-03; 694-22-00; 694-23-00)

The objective of the activities covered by this RTOP are to expand our understanding of fundamental fluid physics/fluids transport phenomena and the effects of gravity on those phenomena through studies which exploit the unique conditions that prevail in a reduced gravity environment. The pursuit of this understanding is directed to a wide range of scientific endeavors of interest to the general fluids community as well as specific applications such as supporting the design and development of advanced technologies/techniques for space-based materials processing and fluid management systems. Because of the wide range of applications and the large disparity of fluid processes/conditions encountered in these applications, the strategy used to address as many critical fluids issues as possible is to concentrate on a much smaller set of reasonably self-contained research topics or areas of fundamental understanding. At the Lewis Research Center (LeRC) the topics/areas of interest include: (1) Phase Transitions (first order and second order); (2) Multicomponent/Coupled Transport Flow; (3) Magneto-Electro- Hydrodynamics; (4) Multiphase Flow; and (5) Capillary Phenomena. In general, idealized simple systems using reference fluids mean ambient temperatures are chosen for initial modeling and experimental work before proceeding to studies of more application specific configurations and conditions.

W92-70679 **674-24-06**
Goddard Space Flight Center, Greenbelt, MD.
CRITICAL TRANSPORT PROPERTIES
S. H. Castles 301-286-5405

We propose to investigate the equilibration near the liquid vapor critical point that was suggested by recent calculation of Onuki and Ferrell. Consider a pure fluid in a flat cell with conducting walls at constant density and temperature. Then, in the absence of gravity, thermal equilibration of the fluid interior following a sudden change of the wall temperature is reached very rapidly. This rapid equilibration could allow microgravity experiments in fluids to be performed which would otherwise be impossible to perform. We propose to make quantitative measurements of the equilibration in He-3, which can directly be compared with predictions.

W92-70680 **674-24-08**
Marshall Space Flight Center, Huntsville, AL.
FLUID DYNAMICS AND TRANSPORT PHENOMENA
Robert S. Snyder 205-544-7755

The objective of this RTOP is to develop experimental and theoretical methods for the study of the effects of gravity on the behavior of fluids undergoing phase transformations. Of particular interest are the quantitative effects of boundary conditions on the nature of the heat and mass transfer processes that accompany the solidification of materials. Experimental and theoretical work will be carried out to understand the electrokinetic properties of particulate suspensions and check the fundamental concepts of the physics of the equivalence principle. Other objectives are to develop a body of data on the conductivity and dielectric behavior of various particulate suspensions and develop a theory to describe how the dielectric constant and conductivity depend on the properties of the suspension, and to test the Einstein Equivalence Principle to a very high accuracy to check fundamental concepts of physics.

W92-70681 **674-25-04**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
METALS AND ALLOYS - CONTAINERLESS SCIENCE
L. A. Lemmerman 818-354-0508

The Metal and Alloys Research and Technology Operating Plan consists of three tasks. The principal objectives of each of the tasks are discussed below. The Acoustic Containerless Science Task objective is to apply single mode acoustic levitation concepts developed in the previous technology development, Multimode Acoustic Research RTOP, to study the containerless processing of glasses and ceramics using microwave heating techniques. The task objectives will include (1) determination of the reaction mechanism, microstructure development and physical properties associated with containerless microwave synthesis of ceramics; (2) development and application of noncontact microwave

techniques for monitoring the energy absorption during processing, and measuring thermophysical properties of containerlessly positioned samples; and (3) theoretical modeling of the acoustic and microwave field effects on glass and ceramic processing. The Electrostatic Containerless Processing Technology objective is the development of the science and technology base required for containerless positioning and manipulation of various materials using electrostatic and dielectrophoretic forces. Experimental and theoretical investigations involved in this task are the development of sample positioning and manipulation capabilities in the environments of wide range of temperature, pressure, and acceleration; the performance of containerless undercooling/solidification experiments in metals, alloys, and glasses in the reduced acceleration environment on board the KC-135; and the performance of charged drop dynamics experiments. The Containerless Studies of Nucleation and Undercooling Task objectives are to utilize containerless manipulation technologies to perform undercooling and heterogeneous nucleation experiments on low melting pure metals and alloys, organic compounds and glass formers; measurements of the physical properties of undercooled melts and glass formers; a determination of the effects of solidification rate on the solute distribution in initially undercooled melts of metallic alloys; and studies of the effects of gravity and the containerless environment on solidification from melt and solution. Experimental methods are based on ultrasonic and electromagnetic levitation techniques using gaseous and liquid hosts and non-invasive measurement methods.

W92-70682 **674-25-05**
Lewis Research Center, Cleveland, OH.
METALS AND ALLOYS
Jack Salzman 216-433-2868
(694-24-00; 694-03-03; 694-22-00; 694-23-00)

The objective of the Metals and Alloys RTOP is to conduct fundamental research on transport behavior of liquid metals to better understand such phenomena as nucleation, pattern selection during solidification, phase separation, diffusion, coarsening, and segregation. Extensive use is made of model materials such as lead-tin alloys and transparent organic analog systems. The ultimate goal is to use this understanding to improve current or develop new theories, models, and ground-based materials and processes. The experience gained also contributes to preparation of materials processing in space, e.g., welding or space mineral processing. Near term targets include definition of parameters for space-based cellular and dendritic solidification experiments, critical re-examination of published work to determine reasons for discrepancies between existing models and theories for dendritic and cellular growth, development of quantitative techniques for observing transparent crystal growth, evaluation of potential of bulk undercooling as a microgravity process, and examination of the zone melting technique for application to advanced metallic materials.

W92-70683 **674-25-08**
Marshall Space Flight Center, Huntsville, AL.
METALS AND ALLOYS
P. A. Curreri 205-544-7763

Control of the solidification of metals and alloys is keyed to gravitational effects such as buoyancy-driven convection. Thus, the objectives of the study are to identify various aspects of solidification phenomena that may be affected by gravity-driven flows, devise and conduct critical experiments in both increased gravity as well as in space, and impact the field of metallurgy by fundamental knowledge through devising better control strategies. Multicomponent metallic systems involve a first-to-freeze component which nucleates and begins to grow, causing the composition ahead of the solidification front to change dramatically. Where it is infeasible or undesirable to provide controlled gradients for a planar solidification front, dendritic growth results. Thus, concentration is one of the more fundamental problems involved in the formation of dendrites. Directional solidification affords a degree of control because unidirectional thermal gradient can be imposed and growth rate regulated. Another important class is the monotectic alloys which have a region of immiscibility. Finally, nucleation and rapid solidification of deeply undercooled melts will be pursued by containerless melting and solidification.

W92-70684 **674-26-04**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
GLASS RESEARCH-GLASS FORMING ABILITY AND CRYSTALLIZATION OF GLASS
L. A. Lemmerman 818-354-0508

The overall objectives of this RTOP are to establish the scientific framework, to provide a data base for the evaluation and interpretation of microgravity-performed glass experiments through ground-based experimentation and theoretical modeling, and to employ ground-based levitation facilities for testing the feasibility of such microgravity experiments. In this program, experimental studies concerning nucleation and crystallization behavior of glasses and theoretical studies involving mathematical modeling for the calculation of critical cooling rates will provide data for interpretation of space experiments. Specific objectives are to understand the relative importance of intrinsic and extrinsic factors in setting the practical glass-forming limits of selected compositions; to develop models for the interpretation of ground-based and flight experiments; and to assess the utility of performing containerless glass-forming experiments on selected compositions.

W92-70685 **674-26-05**
Lewis Research Center, Cleveland, OH.
GLASSES AND CERAMICS
Jack Salzman 216-433-2868
(694-24-00; 694-03-03; 694-22-00; 694-23-00)

The objective of this RTOP is to identify and initiate fundamental research in the areas of glasses and ceramics wherein microgravity related phenomena play an important role. Phase immiscibility in glasses has been initiated as an in-house research effort and an AO proposal was submitted. Research involving order-disorder transitions of ceramic slips and agglomeration of ceramic powders has been sponsored. Though included in combustion science, there is some new work at the University of Colorado on self propagating thermal reactions for the preparation of continuous ceramic networks, metal filled composites. Ceramic powder agglomeration research has been tied in with laser light scattering development in the Microgravity Materials Science Laboratory (MMSL). A new effort in fiber growth has been initiated via an National Research Council (NRC) fellow. Using laser light scattering (LLS), Dr. Rafat Ansari has extensively aided the research of Professor James Cawley of Ohio State.

W92-70686 **674-26-08**
Marshall Space Flight Center, Huntsville, AL.
GLASSES AND CERAMICS
E. C. Ethridge 205-544-7767

The objectives of this activity are to perform studies that utilize the unique capabilities of space processing to investigate particular problems in the science and engineering of glasses and ceramics. These include the study of gravity dependent behavior in melts; the investigation of container induced heterogeneous nucleation effects; the examination of novel techniques and applications for containerless processing of glasses and ceramics; and understanding and defining the limitations of processing in 1-g to support the development of meaningful flight experiments to extend the processes and experiments beyond the limitations imposed by gravity. The experiments can be grouped into two categories, fluids experiments and containerless processing experiments. Fluids experiments include the investigation of phenomena such as bubble motion, containerless viscosity and surface tension measurements, and inviscid fluid fiber pulling experiments. The fluids class of experiments require low-g in order to minimize convection or hydrostatic flow. Containerless processing is the other important class of the glass and ceramic experiments. The difficulty in levitating and melting glasses and ceramics in one-g has had a limiting effect on the development

of the discipline. Recent accomplishments by NASA contractors have further advanced the ability to containerlessly process glasses and ceramics in one-g such that small samples can be processed to above 2000 C in air.

W92-70687 **674-27-05**
Lewis Research Center, Cleveland, OH.
MICROGRAVITY MATERIALS SCIENCE LABORATORY (MMSL)
Jack Salzman 216-433-2868
(694-24-00; 694-03-03; 694-22-00; 694-23-00)

The objective of the Microgravity Materials Science Laboratory (MMSL) RTOP is to maintain and operate a dedicated, well equipped laboratory for the performance of ground-based studies in support of the Microgravity Science and Applications Division flight program. This laboratory is open to scientists from academia, industry, and government. It contains equipment and facilities for simulation and emulation of some aspects of the microgravity environment as well as apparatus chosen to imitate flight apparatus. It is staffed by a small group of engineers and technicians providing a varied background in materials, chemistry, computer science, mechanical engineering, and physics. Funding is required for support of the support service contractor technicians working in the lab, for purchase and maintenance of facilities, for supplies, and for operation of a metallographic laboratory.

W92-70688 **674-28-05**
Lewis Research Center, Cleveland, OH.
GROUND EXPERIMENT OPERATIONS
Jack Salzman 216-433-2868
(694-24-00; 694-03-03; 694-22-00; 694-23-00)

The objective of the activities funded under this RTOP is to provide the manpower, equipment, and facility support necessary to perform reduced gravity experiments in the LeRC 2.2 Second Drop Tower, Zero-Gravity Facility, Learjet, and supporting laboratories. Experiments are conducted to support both principal investigator studies and LeRC in-house studies primarily in fluids and combustion science. Funding is utilized for aircraft flight hour charges, composite rate charges for operations engineering support via a support service contract, engineering design through a university (Case Western Reserve) cooperative agreement, and a variety of facility support hardware, components, and instrumentation.

W92-70689 **674-28-08**
Marshall Space Flight Center, Huntsville, AL.
GROUND EXPERIMENT OPERATIONS
M. B. Robinson 205-544-7774

This RTOP covers work in the area of defining, developing, and conducting experiments using the low-gravity capabilities of the drop tube. Such experiments may be in themselves complete investigations to develop new knowledge or to prove theories, or they may serve as precursors for more extensive experiments to be conducted in space. This RTOP also includes studies and experiments to define the effects of various levels and durations of acceleration perturbations on microgravity experiments.

W92-70690 **674-29-05**
Lewis Research Center, Cleveland, OH.
MANAGEMENT AND PROGRAM SUPPORT
Jack Salzman 216-433-2868
(694-24-00; 694-03-03; 694-22-00; 694-23-00)

This activity provides for the management, coordination, and reporting of the UPN 674 portion of the LeRC Microgravity Science and Applications program. The LeRC Space Experiments Division and Materials Division are responsible for most of the activities covered under the related RTOP's. Funded under this task are program management and reporting activities and the LeRC Program Support charges which include facility usage, computer usage, and instrument pool usage.

W92-70691 **674-29-08**
Marshall Space Flight Center, Huntsville, AL.
CONSULTING AND PROGRAM SUPPORT
B. G. Bass 205-544-7756

The objectives of this RTOP are to provide the necessary scientific manpower to augment the implementation of the Microgravity Science and Applications (MSA) research and technology development effort, and to provide the MSA program with an effective means of interacting with the various scientific communities involved for the purposes of making them aware of the research opportunities offered by the MSA program, stimulating their interest and active involvement in the program, gauging their response to the scientific results being obtained by the program, identifying research areas in which the program should concentrate, initiating in-house research activities in selected topics pertinent to the MSA program, and evaluating the ongoing research effort. The Marshall Space Flight Center (MSFC) will ensure the necessary professional and supporting manpower to implement the MSA research and technology development effort. Also, the stated objectives will be met by actively involving the various research communities in the MSA program through the visiting scientist program. In addition, scientific goals and accomplishments of the program will be documented with this documentation included in the NASA Headquarters data base for access to the scientific community, NASA Headquarters MSAD, and other NASA centers.

Astrophysics Payloads of Opportunity

W92-70692 **689-16-00**
Goddard Space Flight Center, Greenbelt, MD.
ADVANCED COMPOSITION EXPLORER (ACE)
Edward F. Thomas 301-286-8125

The objective of this study is to perform a Phase B definition study of the Advanced Composition Explorer (ACE). The ACE will be operated as an international guest-observer facility to determine and compare the elemental and isotopic composition of several distinct samples of matter, including the solar corona, the interplanetary medium, the local interstellar medium, and galactic matter. These scientific objectives will be achieved by performing comprehensive and coordinated determinations of the elemental and isotopic composition of energetic nuclei accelerated on the Sun, in interplanetary space, and from galactic sources. These observations will be performed by a complement of nine cosmic ray and solar wind monitoring instruments. The approach of this Phase B study is to define the ACE instruments, the spacecraft bus, the overall science mission, and mission integration and test. These definition studies will be managed by the Explorers and Attached Payloads Project (Code 410). The studies will be conducted by the California Institute of Technology, the University of Chicago, the University of Maryland, the Los Alamos National Laboratory, the John Hopkins University/Applied Physics Laboratory, and the Goddard Space Flight Center Sciences Directorates. Contributions to these studies will be made by the Max Planck Institute (West Germany) and the University of Bern (Switzerland) under Letters of Agreement with NASA. Upon successful completion of these studies, NASA and its international partners will proceed into Phase C/D. The products of these definition studies will be a Science Requirements Document, Mission Requirements Document, instrument definitions and specifications, spacecraft definition and specification, and Phase C/D implementation plans for the instruments and the spacecraft.

W92-70693 **689-48-00**
Goddard Space Flight Center, Greenbelt, MD.
FAR ULTRAVIOLET SPECTROSCOPIC EXPLORER (FUSE)
David Mengers 301-286-1032

The objective of this RTOP is to perform a Phase B definition

study of the Far Ultraviolet Spectroscopic Explorer (FUSE) mission. The FUSE instrument will fly aboard its own dedicated spacecraft. It will be operated as an international guest-observer facility to conduct astronomical spectroscopy in the UV spectral range from 1200A to shorter wavelengths, with 100A as the short wavelength goal. Canada and the United Kingdom will be supporting NASA in the Phase B definition study of the FUSE instrument. This RTOP is for the NASA portion of the instrument Phase B study, as well as the spacecraft Phase B study. Upon the successful completion of these studies, NASA will proceed into Phase C/D for the mission, with the international partners, Canada and the United Kingdom, supporting the instrument development. The approach is to perform analyses and trade studies to define the FUSE instrument, the science mission, the spacecraft, and mission integration and test requirements. The instrument and science mission studies will be conducted by the John Hopkins University, the University of Colorado, Stanford University, the University of California/Berkeley, and the Goddard Space Flight Center Engineering and Sciences Directorates. Contributions to these studies will also be made by Canada and the United Kingdom under letters of agreement with NASA. The spacecraft and mission integration and test studies will be conducted by the Goddard Space Flight Center Engineering Directorate. The products of these definition studies will be a Science Requirements Document, a Mission Requirements Document, the instrument definition, a Phase C/D development plan for the instrument, the spacecraft definition, and a spacecraft Phase C/D development plan.

W92-70694 **689-78-00**
Goddard Space Flight Center, Greenbelt, MD.
LAGEOS III
G. W. Ousley, Sr. 301-286-8073
(453-21-40)

It has been suggested that placing another Laser Geodynamic Satellite (LAGEOS) spacecraft into an orbit supplementary to that of LAGEOS I would permit the detection of the Lense-Thirring (frame dragging) effect predicted by General Relativity. The geodetic and frame dragging precessions can be measured via laser ranging to a LAGEOS spacecraft launched into a carefully oriented Earth orbit. Geodetic precession produced as the Earth moves around the sun and frame dragging caused by the Earth's rotation combine to precess the line of nodes of the orbit. Orbital measurement of LAGEOS I would be compared with orbital measurements of a new spacecraft (LAGEOS III) which will have a supplementary orbital inclination. This combined geometry cancels nonrelativistic precession contributions due to the Earth's nonsphericity. The tracking technology required is no different from that presently used for LAGEOS I, but the accuracy requirement for inserting LAGEOS III into the correct orbit is very strict if the nonrelativistic effects are to cancel at the desired level. A report produced by a NASA Headquarters Science Advisory Group concluded that at the 70 pct. confidence level, the recovery accuracy would be in the range of 7 to 17 pct.

Sounding Rockets

W92-70695 **879-11-38**
Goddard Space Flight Center, Greenbelt, MD.
SOUNDING ROCKET EXPERIMENTS
Werner M. Neupert 301-286-3756

The objectives of this RTOP are as follows: (1) to develop solar extreme ultraviolet (EUV) and soft x ray sounding rocket payloads for the purpose of characterizing the physical processes of energy transport and dissipation in the transition region and corona and their relationships to heating of the corona, acceleration of the solar wind, and energy release and dissipation during solar flares; (2) to calibrate, launch, and analyze data from sounding rocket payloads developed under this RTOP; and (3) to correlate flight results with ground-based observations and theoretical models. The approach is to develop instrumentation that can both characterize the spatial morphology of the coronal emission and determine its thermal and non-thermal velocity components via measurements of Extreme Ultraviolet (EUV) emission line profiles over a wide range of transition region and coronal electron temperatures. Activities include definition, design, calibration, and flight of a rocket-borne instrument (called SERTS, for Solar EUV Rocket Telescope and Spectrograph), analysis of resulting data and correlation with co-temporal observations, comparison of results with predictions based on models of coronal heating, solar wind acceleration, and solar flares.

W92-70696 **879-11-48**
Goddard Space Flight Center, Greenbelt, MD.
PROPOSAL FOR A HIGH-ENERGY IMAGING DEVICE (HEIDI) ON A BALLOON
Carol Jo Crannell 301-286-5007

The High Energy Imaging Device, HEIDI, is in the hardware development phase of its program for observations of solar flares during the current solar maximum. The primary scientific objective to be pursued with HEIDI is to image solar flares in hard x rays and gamma rays. HEIDI is based on the technique of Fourier transform imaging and utilizes modulation grid collimator optics that ultimately will provide full-Sun imaging with 2-arcsecond resolution over the energy range from 20 to 700 keV at time resolutions from 0.1 to 2 s. For the first flight scheduled for June 1992, HEIDI will employ two rotating modulation collimator (RMCs), each composed of a matched pair of high-Z collimator grids separated by 5.2 m. The two subcollimators provide slit spacings corresponding to angular dimensions of 11 and 25 arcseconds FWHM which correspond to a 5 to 40 arcsecond range of measurable scale sizes. A 9 cm diameter x 1.5 cm thick NaI(T1) scintillation spectrometer will serve as the detector behind each RMC. The RMCs are mounted within a telescope canister that will be pointed to an accuracy of 0.1 degree. A canister mounted aspect system provides absolute fine pointing knowledge to 0.2 arcsecond every 20 ms. An adaptation of the LASER beam steering technique will enable off-SUN pointing with the solar aspect system for calibration of the hard x ray imaging system with non-solar sources. The instrument has an effective area of 30 sq cm and is designed for a one-day duration balloon flight at an altitude of 40 km or higher. The payload may be readily upgraded to 4 RMCs with an effective area of 130 sq cm.

W92-70697 **879-11-48**
Marshall Space Flight Center, Huntsville, AL.
MAX '91 SOLAR BALLOON PROGRAM
John M. Davis 205-544-7600

NASA Headquarters has recognized the unique opportunity for obtaining scientific observations at the next solar maximum from instruments flown to balloon altitudes (120,000 ft) for extended periods of time (15 to 30 days). A High Resolution Gamma Ray and Hard X Ray Spectrometer (HIREGS), Dr. Robert Lin, University of California at Berkeley (UCB), Principal Investigator, has been selected for flight as part of the Max '91 Initiative. The HIREGS investigations will be managed and funded through MSFC. The program will consist of a test flight to take place in CY-91 and a long duration flight in CY-92. A definition phase has been completed and UCB has been awarded a continuing grant for phase C/D.

W92-70698 **879-31-38**
Marshall Space Flight Center, Huntsville, AL.
A SOUNDING ROCKET PROGRAM FOR CORONAL HIGH ENERGY PHENOMENA
John M. Davis 205-544-7600

A 3-year sounding rocket program is planned to observe the solar corona through imaging the x ray emission in the wavelength range 1.4 to 60 Angstrom. The observations will be interpreted in both a local sense as a measure of surface activity and as a global tracer of the magnetic dynamo process. Specific scientific objectives have been chosen to support the Max '91 and Solar-A

programs with which the two proposed flights will be coordinated. They are the location of high temperature materials (Te greater than 5x10(exp 6) K) within active regions by observation of its characteristic radiation, i.e., photon energies greater than 2 keV and its correlation with regions of maximum shear in the magnetic field, the occurrence of solar flares, and the hard x ray emission seen in high energy images. During the first year an existing grazing incidence primary mirror will be repolished and coated to improve image contrast by improving the encircled energy response and to extend the mirror's short wavelength cut-off below its current value of 7 Angstrom. The development of a new imaging, high energy detector with an intrinsic energy resolution DELTAE/E of 0.3 will be undertaken to complement the improved mirror performance. These improvements will be incorporated into the payload, which will be flown twice, in 1992 and 1993, in support of the Max '91 and Solar-A programs.

Mission Operations and Data Analysis

W92-70699 **889-59-00**
Goddard Space Flight Center, Greenbelt, MD.
NEPTUNE DATA ANALYSIS
B. J. Conrath 301-286-6088

This RTOP supports advanced analysis and interpretation of data acquired by the Voyager 2 spacecraft during the Neptune encounter. Task 1 consists of an investigation of the thermal structure, dynamics, and cloud properties of Neptune's atmosphere. Data from the Voyager infrared spectroscopy experiment (IRIS) are used along with other Voyager and ground-based data. Task 2 addresses the bursty Neptune radio emission and its origin. Voyager radio, magnetometer, and solar wind plasma data are analyzed. Task 3 is a study of the hydrocarbons in Neptune's atmosphere. The primary data source to be used is that from Voyager IRIS. Task 4 consists of analyses of the Voyager 2 Plasma Science Experiment (PLS) electron observations in the vicinity of Neptune.

W92-70700 **889-59-00**
Ames Research Center, Moffett Field, CA.
NEPTUNE DATA ANALYSIS
W. J. Borucki 415-604-6492

The major objectives of this RTOP are: (1) to search for lightning in the atmosphere, determine its latitude longitude distribution, and determine the energy dissipation rate of lightning activity; (2) to determine the scattering properties of Neptune's and Triton's atmospheres; and (3) to constrain the structure and particle properties of the Neptunian ringmoon system. The approach is to analyze the images obtained by the Voyager 2 spacecraft specifically for these purposes and to conduct a parameter study with a theoretical model to determine the parameters needed to specify the scattering properties of the atmosphere.

W92-70701 **889-59-00**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
NEPTUNE DATA ANALYSIS
J. F. Appleby 818-354-3943

This group of 13 research tasks addresses a range of data analysis and interpretation problems based on Voyager 2 observations at Neptune. Specifically, the science objectives encompass the use of radiative transfer models to investigate the planet's atmospheric structure including the global energy balance, composition, temperature, and cloud properties, and the use of Voyager data sets to study Triton's wind fields, Neptune's rings, and to search for small satellites. Voyager PPS, IRIS, and imaging data and Earth-based observations are used to study surface characteristics of Triton including its thermal history, topographic relaxation, solid volatile transport, solid-state greenhouse processes, spectral reflection properties (geometric and Bond albedos, phase integrals, and photometric functions versus wavelength), and microphysical structure. Data from radio occultation experiments were used to infer the helium-to-hydrogen abundance ratio in Neptune's atmosphere. Radio science investigations are also used to improve our knowledge of Neptune's gravitational field and ephemeris. The approach makes use of direct inversion algorithms to determine temperatures from the infrared data and sophisticated radiative transfer/aerosol models to examine the solar reflection spectra. The best available ground-based and other spacecraft data are used together with the Voyager measurements to take advantage of the unique spatial, angular, and wavelength coverage available from Voyager data. Improved solid state greenhouse models are developed and applied to Triton's regolith structure. Algorithms are also developed for creating maps of normal reflectances from Triton imaging data. This RTOP also includes extensive work on data archiving, cataloging, and dissemination.

OFFICE OF SPACE OPERATIONS

Advanced Systems

W92-70702 **310-10-23**
Goddard Space Flight Center, Greenbelt, MD.
SOFTWARE ENGINEERING TECHNOLOGY
Frank E. McGarry 301-286-6846
(506-44-31; 310-40-49)

The objective of this RTOP is to identify, develop, evaluate, and refine software engineering technology to be applied to the software development process in NASA. This is accomplished through the Software Engineering Laboratory (SEL), which measures and assesses software engineering technologies within the Flight Dynamics Division (FDD). The SEL measures all software produced by the FDD to support GSFC missions. Successful technologies are incorporated into the FDD software development process.

W92-70703 **310-10-26**
Goddard Space Flight Center, Greenbelt, MD.
FLIGHT DYNAMICS TECHNOLOGY
Ken Galal 301-286-9216

The objective of this RTOP is to develop, evaluate, and demonstrate new technology for flight dynamics in the Tracking and Data Relay Satellite System (TDRSS), Space Transportation System (STS), and Space Station Freedom (SSF) era, encompassing algorithms, techniques, software, and system configurations pertaining to attitude and orbit determination/prediction/analysis for both ground-based and onboard applications. The technology developed under this RTOP supports the Office of Space Operations in the areas of mission computing and analysis, TDRSS operations, and data processing. Research efforts will be divided into two tasks covering attitude and orbit studies. Experience gained in each research area will be shared so that each task may take advantage of any advancements that may have a parallel application. The tasks are as follows: (1) the advanced attitude determination in which advanced, generic attitude methods will be studied and developed; and (2) the advanced orbit determination in which advance orbit determination methods will be studied and developed.

W92-70704 **310-10-60**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
ASTROMETRIC DEVELOPMENT TECHNOLOGY
R. P. Linfield 818-354-2806
(310-10-63)

The objective of this RTOP is to design and demonstrate

improved techniques of astrometric data acquisition and analysis as used by the Deep Space Network (DSN) to support spacecraft navigation. Central to this goal is quantifying and reducing the limiting error sources for various radio and optical tracking data types. Starting from an understanding of the underlying physics, potential error sources are studied to reduce their impact on the final navigation observables. Deep-space navigation is limited by uncertainties in the measurement of components of spacecraft position and velocity in the plane of the sky. Thus, a major thrust is the refinement of methods of spacecraft angular measurement using various astrometric techniques, primarily Very Long Baseline Interferometry (VLBI). Current efforts focus on three areas. The first is atmospheric propagation effects: their statistical properties and methods of calibrating them. The second area is optimal observing strategies for differential spacecraft-quasar measurement. The third area is instrumental effects in the ground observation systems which affect the phase measurements of spacecraft tones. In the next several years, demonstrations of differential angular measurements with accuracies approaching 1 nanoradian will be made on Magellan and Galileo, with the aim of achieving such accuracy routinely by the late 1990s. To advance the capability for target-relative navigation, improvement of the tie between the planetary ephemeris and the radio reference frame is being pursued using several methods. Evaluation of optical tracking techniques will determine their potential for application to future laser-equipped spacecraft. Both filled-aperture and interferometric devices will be considered. The instruments and errors will be studied, in order to optimize the ultimate performance of the technique. The current focus is on data and error analysis for filled aperture telescopes and design compatibility for the Deep Space Optical Reception Antenna (DSORA) Telescope that is being developed in RTOP 67.

W92-70705 **310-10-61**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
GPS-BASED DSN CALIBRATION SYSTEM
Stephen M. Lichten 818-354-1614
(310-10-60; 310-10-63)

The goals of RTOP 61 are to improve the accuracy and efficiency of deep space tracking by using Global Positioning System (GPS) receivers operating at each Deep Space Network (DSN) site and at other locations worldwide. The GPS tracking data can be used to: calibrate the tropospheric delay at each DSN site; monitor variations in Earth orientation each day at the cm-level; calibrate DSN tracking site coordinates to the geocenter with cm-level accuracy; and synchronize DSN clocks worldwide to better than 1 nanosecond and clock frequency to 1 part in 10(exp 14). Presently, some of these calibrations are made with very long baseline interferometry (VLBI) observations of quasars. However, the DSN has limited resources and cannot collect the quasar and spacecraft data at the same time. The GPS approach relies on a separate data collection system. The use of GPS data for these calibrations can free up significant amounts of DSN antenna time, increase the percentage of DSN resources used for deep space tracking, as opposed to support and calibration measurements on other sources, and simplify data reduction. In addition, since the GPS data are collected independently, GPS can provide calibrations simultaneously with the deep space measurements, thus reducing much of the effort in modeling and extrapolating these quantities to the time of the spacecraft tracking. Incorporating GPS calibrations will enable both more accurate and more efficient operation of the deep space network. Enhanced accuracy, for example, will result from better troposphere calibrations, improved time resolution for Earth orientation, and determination of geocentric coordinates for DSN antennas. In instances where GPS calibrations allow more DSN antenna time to be dedicated to spacecraft tracking and telemetry, increased efficiency and productivity will result. RTOP 61 includes: system design; performance analysis; error analysis and parameter estimation software development; study and demonstrations of the use of GPS for DSN calibrations and mission support; and demonstrations of high precision tracking techniques on the GPS satellites and on future Earth orbiters.

W92-70706 **310-10-62**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
FREQUENCY AND TIMING RESEARCH
L. Maleki 818-354-3688
(310-10-60; 310-20-64; 310-20-66)

The objective of this RTOP is to design, analyze, develop, and demonstrate the technology of precise frequency and timing for the Deep Space Network (DSN) mission and science support. The long term stability goal is the demonstration of parts in 10(exp 17) capability for averaging intervals between 1 second and 10(exp 5) seconds in the late 1990's. The near term work planned is in two areas: (1) the generation of stable frequencies with the trapped ion frequency source for stability of parts in 10(exp 16) at averaging intervals greater than a few thousand seconds, and with the superconducting maser oscillator for parts in 10(exp 16) at averaging intervals less than 1000 seconds, and the generation of spectrally pure signals at 8.4 and 32 GHz frequencies with the sapphire dielectric resonator oscillator; and (2) the distribution of frequencies with stability of parts in 10(exp 17) through the development of fiber optics systems including electronically stabilized fiber optic cables. A system will be developed to distribute reference signals within the DSN complex through the antenna front end, where immunity to temperature and vibration is required.

W92-70707 **310-10-63**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
SPACE SYSTEMS AND NAVIGATION TECHNOLOGY
Lincoln J. Wood 818-354-3137
(310-10-60; 310-10-61; 310-20-67)

The long-term objectives are to: (1) study and determine system-level requirements for new navigation technologies; (2) determine the Deep Space Network (DSN) capabilities needed to meet the anticipated navigation requirements of future missions; (3) investigate new navigation measurements with the goal of increasing navigation accuracy achievable with the DSN, while simultaneously reducing the amount of DSN resources needed; and (4) develop a synergistic relationship with advanced mission planning teams that promotes the optimum growth of NASA (both DSN and spacecraft) navigation capability. In support of its objectives, the RTOP develops techniques for both increasing the accuracy of the DSN-based navigation process and increasing the efficiency, reliability, and flexibility of that process. Radio tracking applications to difficult new mission classes, such as low-altitude planetary orbiters, outer-planet satellite tours, and earth-orbiting radio astronomy missions are investigated. Achievable orbit determination accuracies, factors limiting accuracy, and DSN resources required for various navigational data types are evaluated for representative missions, by means of numerical and analytical studies. Investigations into improved modeling needed for use of high-accuracy radio metric data are conducted. Data strategies planned for the future are demonstrated, where possible, using existing spacecraft in flight. New navigation approaches and concepts, such as navigation with communication links at optical frequencies, are investigated and their system impact on technology requirements identified. The RTOP also focuses on reducing mission operations costs by increasing the efficiency and reliability of radio metric data processing. The development and demonstration of portable graphical user interfaces for the navigation operations software is underway, to improve user productivity by conveying essential information in concise graphical form.

W92-70708 **310-20-33**
Goddard Space Flight Center, Greenbelt, MD.
NETWORK TECHNOLOGY
George C. Kronmiller, Jr. 301-286-7313

The objective of this RTOP is to investigate the applicability of new technology in the Tracking and Data Relay Satellite System (TDRSS) era. Selected technology will be investigated by means of feasibility studies, prototype development and demonstration, and by cost and reliability impact studies. A major goal is to investigate the potential for use of Radio Frequency (RF) to

Intermediate Frequency (IF) fiber optic technology in future ground station applications. The extremely wide bandwidth and low loss available in fiber optic cables makes this technology an attractive alternative to coax cable and waveguide. The task will concentrate on the feasibility of transmitting RF signals using fiber optics. In more conventional fiber optic applications, digital signals are transmitted using the electro-optic components as switched devices whereas this experiment will utilize these devices in a linear mode. Another major goal is to investigate new modulation and coding techniques for the TDRSS RF channels. The increasing use of satellite communications in conjunction with growing user sophistication has imposed, and will continue to impose, the requirement to support increasingly higher data rates and data throughput. Implementation for data rates of 300 Mbps and higher will be studied and prototyped, as applicable.

W92-70709 **310-20-34**
Goddard Space Flight Center, Greenbelt, MD.
SYSTEMS ENGINEERING TECHNOLOGY FOR NETWORKS
Keiji K. Tasaki 301-286-8871

The objectives of this RTOP are to conduct research into methods and techniques with which emerging systems engineering technologies potentially applicable to the ground segment of the Space Network (SN) could be evaluated, and to actually evaluate candidate technologies for possible use within the SN. Currently, there exists no formal method of evaluating new concepts, algorithms, software packages, and hardware components which may potentially be beneficial to the SN ground segment facilities, including the Network Control Center (NCC), the White Sands Ground Terminal (WSGT), the Second Tracking and Data Relay Satellite System (TDRSS) Ground Terminal (STGT), the Space Network Control (SNC), etc. Under this RTOP, structured and formalized methods and techniques, which will enable us to evaluate quantitatively the effectiveness of emerging technologies, will be investigated. The investigation will be conducted through the use of modeling techniques along with well-defined measures/metrics which will characterize the state of the SN. The impact of introducing a new component into these facilities could then be determined using such formal methods.

W92-70710 **310-20-35**
Goddard Space Flight Center, Greenbelt, MD.
OPTICAL COMMUNICATIONS
Michael A. Krainak 301-286-2646

The objective of this RTOP is to develop an entirely new type of multi-access communication system for future NASA data relay systems. This new approach, for which a patent application has been filed, will utilize optical frequencies and has the potential to provide both order of magnitude increases in data rate, as well as large decreases in size, weight, and power for the geosynchronous relay satellite. Return link data rates of 10 to 50 Mbps appear feasible with an optical multi-access (OMA) terminal on the geosynchronous satellite which will require approximately one square foot of nadir viewing area. The weight and power estimates are 100 to 200 lbs and 100 to 200 watts respectively. Design studies on the low Earth orbiting user terminal are not yet complete, but initial results indicate that a very small opto-mechanical system will meet all requirements. The approach for this task is to use a single, spacecraft mounted telescope on the geosynchronous relay satellite. This wide field of view optical system images incoming optical signals onto moveable pickup arms in the focal plane. One such pickup is assigned to each low Earth orbiting user during a communication session. The user terminal is configured in a conventional manner using a small telescope within a hemispherical coverage 2-axis gimbal. A laboratory proof of concept OMA system will be developed during FY-91 to FY-92. This system will be tested, evaluated, and demonstrated in FY-93. The development of a full performance feasibility model system will also be initiated in FY-93.

W92-70711 **310-20-38**
Goddard Space Flight Center, Greenbelt, MD.
NETWORKS COMMUNICATIONS TECHNOLOGY
T. E. Butler 301-286-7335

The objectives of this RTOP are to establish a NASA Communications (Nascom) Open Systems Interconnections (OSI) Protocol (NOSIP) testbed to investigate techniques for interfacing with OSI networks and to expand the functionality of the Virtual Channel Sorter Multiplexer (VCSM) prototype to include a rudimentary gateway function for Consultative Committee for Space Data Systems (CCSDS) to Fiber Distributed Data Interface (FDDI) protocol conversion, and perform benchmark throughput testing. The objectives are being pursued under two tasks. The first task involves analyzing and assessing the relative merits of OSI network technology for application in Nascom networks. The second task is being pursued in cooperation with the Data Systems Technology Division to procure hardware and develop software that can perform the routing of CCSDS protocols via FDDI protocol. The approach for this RTOP is to focus on two tasks which are selected to cover areas which can provide the maximum benefits to the Division, Directorate, Center, and NASA. Each task is structured as a 2 or 3 year effort for analysis, simulation, and prototype development. Hardware and software development are included. The RTOP effort on each task will culminate in a report, software package, or prototype equipment. Follow-on development work, if any, will use research and development funds.

W92-70712 **310-20-46**
Goddard Space Flight Center, Greenbelt, MD.
ADVANCED SPACE SYSTEMS FOR USERS OF NASA NETWORKS
R. P. Hockensmith 301-286-9067

The objective of the work under this RTOP is to achieve technological advances in radio frequency (RF) and optical systems, antenna subsystems and associated control technology, on-board data storage systems, and in telecommunications coding. These developments will satisfy future requirements of users of NASA networks (spacecraft, space platforms, and space transportation system payloads) that require near-global coverage through operational and evolving data relay satellite systems, and other networks as appropriate. The approaches for accomplishing the objective are to: (1) identify the basic operational space flight requirements; (2) investigate active and passive components and antenna systems; (3) investigate methods of reducing and controlling torque noise induced for the steering of large high gain antennas; (4) investigate methods of high density and high rate recording storage and playback; (5) investigate improvements in telecommunication coding of spacecraft generated data; (6) develop system designs to permit user projects to specify proven, reliable hardware with a high confidence level in the performance capability and low cost within the required procurement cycle; and (7) exploit necessary improvements in testing techniques that properly characterize these critical systems.

W92-70713 **310-20-64**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
ADVANCED TRANSMITTER SYSTEMS DEVELOPMENT
Rob Hartop 818-354-3433
(310-20-65; 310-20-69)

The objective of this RTOP is the design, development, and demonstration of advanced transmitter systems that will enhance performance, reduce costs, and improve the reliability of the Deep Space Network transmitter functions, including uplink command capability, emergency commanding, radio science, navigation, and radar astronomy. The design of a state-of-the-art transmitter system from the output of the frequency standard at 100 MHz or higher to the feedhorn output at X- or Ka-band is in progress. This transmitter system will feature advanced technology in several areas, including those that are required for very high phase stability and high reliability, and complete microprocessor monitoring and control. The resulting transmitter technology will be applicable to many NASA anticipated requirements including support for future robotic and manned missions to the Moon and Mars. Techniques

will be developed for combining multiple high power sources while receiving multiple frequencies in an efficient and versatile manner, including beam waveguide antenna environments. Advanced dichroic plates of new design are being developed for frequency separation and simultaneous operation, including up and down links in the same and different frequency bands.

W92-70714 **310-20-65**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
ANTENNA SYSTEMS DEVELOPMENT
Alan Cha 818-354-3509
(310-20-64; 310-20-69; 310-20-70)

The objectives of this RTOP are to develop electromagnetic and structural mechanical technology to increase the capabilities of the large antennas in the Deep Space Network (DSN) for mission support. Capability improvements include increased frequency band coverage, simultaneous multi-frequency operation, increased gain, and improved noise temperature performance, and reduced maintenance and operations costs. Recent developments completed in this RTOP include wideband beam waveguide (BWG) optics and structural design approaches incorporated in the newly operational Deep Space Station (DSS)-13 BWG antenna. Array feed, electronic tracking feed, improved reflector surface model based on microwave holography measurements, and active reflector surface control techniques are some of the ongoing tasks which are critical in realizing an estimated 6 to 8 dB of link performance improvement of Ka-band over X-band. The present objectives are to: (1) develop multiple frequency-band antenna capabilities at DSS-13 to cover 1 to 45 GHz including simultaneous dual-frequency and uplink/downlink operations for spacecraft missions; (2) achieve high accuracy and stable Radio Frequency (RF) beam pointing and improve effective antenna surface quality at 32 GHz for outer planet missions such as Cassini; (3) extend BWG antenna technology to the 34 m and existing 70 m antennas; and (4) demonstrate autonomous real-time antenna fault diagnosis technology to improve operational reliability and availability. To achieve these objectives, accurate computer analysis software appropriate to large high-frequency reflectors is used. Demonstrations and tests are planned to verify analytical models and understand critical areas needing cost-effective improvement. A goal is to provide technology and to enable informed decisions on when and how to deploy Ka-band DSN mission support, particularly as they apply to the new DSS-18 antenna.

W92-70715 **310-20-66**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
RADIO SYSTEMS DEVELOPMENT
J. Bautista 818-354-6994

The objectives of this RTOP are to develop and demonstrate low-noise amplifier technology that will lead to ground-based improvements in spacecraft communications and navigation during deep space missions. The improvements sought are lower noise temperatures and increased bandwidths, reduced implementation costs, and increased reliability of receiving equipment and cryogenic (cooling) systems. These improvements address both present and future Deep Space Network (DSN) navigation, telemetry, radar, and radio science needs. A key figure of merit in the specification of the communications down link is the gain of the receiving antenna divided by the system noise temperature (G/T). This RTOP addresses the challenge of keeping the system noise temperature as low as technology economically permits over the present and future DSN frequency bands. The immediate concern of this RTOP is the development of broadband, high gain, low-noise amplifiers at 32.00 and 33.68 GHz which are compatible with array feed systems. Amplifiers using the principle of microwave amplification by the stimulated emission of radiation (masers) and high-electron mobility transistors (HEMT's) are being developed. In the next year, masers and HEMT's will be designed and demonstrated to have noise temperatures below 7 and 30 K, respectively. In addition, to protect HEMT's from radio frequency interference (RFI), filters utilizing high temperature superconductors will be developed. The analytical tools and measurement systems needed to characterize the associated materials and devices for the design of practical amplifiers are continuing to be developed. There is also a continuing effort to develop a more reliable 1.6-K cooling system appropriate for use on antennas with beam waveguide feed systems to greatly improve maser performance. For example, on cooling an 8.4-GHz maser from 4.5 to 1.6 K the gain in dB increases three times while the noise temperature is reduced by a factor of three.

W92-70716 **310-20-67**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
OPTICAL COMMUNICATIONS TECHNOLOGY DEVELOPMENT
J. Lesh 818-354-2766
(310-10-63; 310-20-60; 646-00-00; 506-59-41; 315-91-60)

The objective of this RTOP is to develop and demonstrate a reliable and efficient optical communications and tracking capability for use with Deep Space Network (DSN)-supported missions of the future. The work will concentrate on the definition, design, development, and analysis of communications and tracking systems that could support such missions, and will include the development of high-leverage technologies that have a major influence on the character of those systems. This RTOP will involve the design, development, fabrication, and testing of laboratory and other ground-based demonstrations of the technology for optical communications and tracking. Flight demonstrations of the technology will be pursued only through the conceptual design and planning stages, so that appropriate sources of funding can be identified for the execution of the flight demonstrations. Optical techniques for communication and tracking are expected to be of greatest value when used between planetary spacecraft and an Earth-orbiting communications and tracking terminal. However, studies indicate that even ground-based optical systems could provide communications and tracking performance that exceeds current DSN capabilities by at least 10 dB. Accordingly, this RTOP will also include examination of the design, cost, and performance factors of ground-based systems. These studies will emphasize identification of the key factors which determine performance, as well as estimation of the uncertainties in those factors. Major activities for the RTOP are the definition and planning for a ground-based research and development facility, formulation, and validation of an atmospheric weather model based on existing satellite-collected data, and the establishment of a network of three autonomous atmospheric visibility monitoring (AVM) telescopes.

W92-70717 **310-30-69**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
DSS 13 INSTRUMENTATION AND CAPABILITIES
Mark Gatti 818-354-2123
(310-20-66; 310-30-73; 310-10-62; 310-20-65; 310-10-60; 310-20-64; 310-30-70)

The objective of this RTOP is to provide the new Deep Space Station (DSS) 13 34-meter antenna at Goldstone with the basic capabilities required to achieve the activities planned in the Advanced Systems Program in support of future Deep Space Network (DSN) capabilities, enhancements, and increased efficiencies. The majority of these activities involve 32 GHz technology development and demonstrations of the new beam waveguide antenna at DSS 13. The basic capabilities, referred to as core capabilities, are determined based on the needs of the station users. Core capabilities will be implemented in a timely manner consistent with the future goals for the anticipated use of the facility. The major near-term capabilities are driven by the Mars Observer Ka-Band Link Experiment (KABLE), and the plan to decommission the existing 26-meter antenna. These capabilities include X/Ka-band and S/X-band receive strings, precision pointing, and monitor and control. The X/Ka-band string consists of X-band High-Electron Mobility Transistors (HEMT's), Ka-band Masers and HEMT's, frequency converters, digital telemetry processors, associated frequency and timing, and related support services. The work units in this RTOP span a variety of disciplines and provide for antenna calibrations, water vapor radiometers, low noise amplifiers, digital receivers, feeds and front-ends, and monitor and control. Certain capabilities, of interest only to single users, will be provided by those users. At the end of such a research program,

an agreement may be reached whereby this new capability is absorbed into the core facility of DSS 13 and support for the capability is continued. Finally, there is a work unit which will provide engineering support to users, and to the station personnel in the event of component failure. The core capabilities to be provided by this RTOP will be realized through the close cooperation and careful coordination of the efforts of related RTOP's, and by anticipating the future needs of the facility. In this way the new technologies to be used in the DSN may be sufficiently tested in a well supported research and development environment.

W92-70718 **310-30-70**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
NETWORK SIGNAL PROCESSING
Sami Hinedi 818-354-3016
(310-30-65; 310-30-66; 310-30-69; 310-30-72)

The purpose of the RTOP is to investigate, develop, test, and demonstrate advanced signal processing systems which enable the Deep Space Network (DSN) to plan and achieve current and future performance requirements with improved reliability, maintainability, and operability. Key objectives for this RTOP are to: (1) develop signal processing techniques and algorithms for an array feed in order to improve antenna gain performance at Ka-band relative to existing single feed DSN antenna system by 3 to 5 dB; (2) develop techniques for generating array feed error signals to provide electronic antenna pointing capability at Ka-band, thereby reducing antenna pointing losses; (3) develop arraying techniques to improve telemetry Signal to Noise Ratio (SNR) performance by 1 to 3 dB relative to existing single-station DSN systems; (4) field test a new DSN spectrum surveillance system with sensitivity comparable to the weakest spacecraft signals; (5) develop high speed sampling and digitizing circuits to enable wider bandwidth front-end digital signal processing; (6) develop custom Very Large Scale Integrated (VLSI) circuits for signal processing whenever cost, speed, complexity, size, or reliability dictate; (7) develop architectures and technologies for telemetry links operating in excess of 100 Mbits/sec. The work outlined in this RTOP will be achieved by exploiting advanced digital signal processing (DSP) technologies and algorithms, including general purpose and custom VLSI chips. During FY-92, the main tasks are to: (1) conduct a proof-of-concept field demontration of Ka-band array feed signal processing system; (2) demonstrate Quadrature Phase Shift Keying (QPSK) and Unbalanced QPSK (UQPSK) telemetry data extraction for a 15 MHz bandwidth advanced receiver; (3) demonstrate two-station full spectrum combining and carrier arraying at Goldstone DSN complex; (4) demonstrate a 1-bit high speed sampling and digitizer microcircuit implemented with gallium arsenide (GaAs) technology; (5) perform design and layout of a 40 MHz Complex Digital Signal Processor (CDSP) with application to the Search for Extraterrestrial Intelligence (SETI) spectrum analyzer; and (6) perform a trade-off study between architecture and related technologies for telemetry links in excess of 100 Mbits/sec.

W92-70719 **310-30-71**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
COMMUNICATIONS SYSTEMS RESEARCH
Fabrizio Pollara 818-354-4287
(310-30-70)

The objective of this RTOP is to perform communication systems research required to meet the needs of present and future Deep Space Network (DSN) supported missions. This effort is focused on improving space communication capability at low cost, through research and development in key areas of coding and modulation for efficient data transmission, including up-link command coding. Coding/decoding (error-correcting and source) and modulation/demodulation techniques for future missions will be investigated and demonstrated. A coding experiment on Galileo will demonstrate a coding gain of more than 1 dB over the original Galileo code. The longer-term goal involves new research into channel codes and source codes for improved data returns within power and bandwidth limits. Communication efficiency will be improved for current codes and technology. For example, sometimes changes in decoding techniques can improve error performance for already existing codes. Much of this work uses previously developed analysis and computer simulations in evaluating proposed and planned changes in hardware or operations; the development of these simulations is an ongoing activity of this RTOP. Coding ideas developed and/or analyzed in this RTOP will be demonstrated, and recommendations will be made on their potential use. Support of the Big Viterbi Decoder, as needed, will become part of this RTOP after a successful 1991 Galileo experiment and transfer to DSN Implementation. The DSN system engineering analysis will support flight demonstrations and planning to test technologies in related RTOP's, accelerate technology transfer to implementation, and characterize operational performance of future systems; especially for Ka-band.

W92-70720 **310-40-37**
Goddard Space Flight Center, Greenbelt, MD.
HUMAN-TO-MACHINE INTERFACE TECHNOLOGY
Walt Truszkowski 301-286-8821

The objectives of this RTOP are to realize developmental and operational improvements in user/machine interfaces and interactions in control center and data processing systems by identifying, researching, and developing state-of-the-art concepts, models, and tools for supporting the engineering of these interfaces and interactions. The intent is to apply recent advances in human factors analysis, data and information base management, semantic modeling, and artificial intelligence (AI) to human/machine interface and interaction problems in order to realize the desired improvements. The approach to be followed in realizing the objectives is to provide tools and environments to support the evaluation, and use of operational interfaces. The evaluation will be supported by a tool designed to qualify and quantify human performance for on-line activities. Intelligent tutoring systems will provide training to both managers and technicians in the proper use of their respective systems. The RTOP is a system level RTOP supporting Tracking and Data Relay Satellite System (TDRSS) operations, mission operations, mission support computing, and general systems engineering activities.

W92-70721 **310-40-45**
Goddard Space Flight Center, Greenbelt, MD.
MISSION OPERATIONS TECHNOLOGY
Dan Mandl 301-286-4323

Control center systems are becoming more sophisticated and spacecraft operations are becoming more complex with the advent of sophisticated on-board spacecraft computers. Typical functions performed by a Flight Operations Team (FOT) under the pressure of a timeline are to: monitor and analyze large amounts of telemetry data from a host of instruments and platforms; diagnose and predict subsystem failures; and develop strategies for corrective action. Expert systems and other automation techniques have been developed to help the FOT perform their increasingly complex tasks reliably and quickly. Examples of such systems are the Graphical Spacecraft Monitoring System (GSMS), and the Backup Control Mode and Analysis System (BCAUS), two systems developed for the Gamma Ray Observatory (GRO) Payload Operations Control Center (POCC). These systems use a state-of-the-art two and three dimensional real-time color graphics, expert system.

W92-70722 **310-40-47**
Goddard Space Flight Center, Greenbelt, MD.
EXPERT SYSTEMS FOR AUTOMATION OF OPERATIONS
Walt Truszkowski 301-286-8821

Work under this RTOP will demonstrate the potential of expert systems to automate operations and increase operator capacity by handling routine, labor-intensive tasks and by reducing human task complexity. The development and demonstration of pilot projects which capture functions of control centers will facilitate the transfer of this technology into operations. Under this RTOP, expert systems will be developed and applied in selected areas to reduce, eliminate or assist human operator decision making.

Projects will be established with the operational divisions to develop proof-of-concept systems and transfer the technology for operational use. Systems will be developed with a phased approach to allow for early hands-on demonstration of kernel functions to potential users. The transfer of techniques, methodologies and expertise to the operational divisions will be a major goal. This RTOP will also address some of the knowledge management issues associated with both single and multiple cooperating expert systems, and will generalize from specific prototypes to multi-application frameworks. It will also support the embedding of expert systems in data systems.

W92-70723 **310-40-48**
Goddard Space Flight Center, Greenbelt, MD.
DATA STORAGE TECHNOLOGY
Ward Horner 301-286-5804

The objective of this RTOP is to develop systems technology and evaluate storage components to provide high performance, low life cycle cost data storage systems to meet data capture, buffering, processing, and distribution requirements for future space missions. Commercial tape and disk subsystems have evolved functional, performance, and cost characteristics which now make them candidates in the development of high performance, cost effective mass storage systems. These systems will require the use of commercially available disk farms with appropriate failure mode control to ensure data integrity. NASA specific Very Large Scale Integration (VLSI) controllers for management of spacecraft telemetry processing and flow will be developed for use with commercial parallel disk controllers, disk drives, and standard interfaces. These elements will be used to prototype advanced data storage system architectures adaptable to a range of mission data rates. These systems will then be integrated with prototype VLSI telemetry handling systems being developed for the Data Interface Facility (DIF) and Enhanced Packet Processor to perform higher level telemetry processing and routing functions.

W92-70724 **310-40-49**
Goddard Space Flight Center, Greenbelt, MD.
ADVANCED ENVIRONMENTS FOR SOFTWARE AND SYSTEM DEVELOPMENT
Sylvia B. Sheppard 301-286-5049

The goal of this RTOP is to develop and evaluate systems-level concepts and technologies that will be used to optimize the management, development, operation, and evolution of Mission Operations and Data Systems Directorate (MO&DSD) data systems. Major objectives are: (1) the development of a state-of-the-art performance modeling environment consisting of an integrated set of tools and support services to facilitate the use (and reuse) of data system modeling; and (2) the definition and phased prototyping of an advanced software engineering environment. The RTOP approach is to develop or acquire associated tools and techniques, apply the tools and techniques to representative problems, and evaluate both the techniques and the results prior to full utilization in MO&DSD. This is a system-level RTOP supporting mission operations, mission support computing, spacecraft data acquisition, data processing, and Tracking and Data Relay Satellite Systems (TDRSS) operations.

W92-70725 **310-40-51**
Goddard Space Flight Center, Greenbelt, MD.
ADVANCED TELEMETRY PROCESSING TECHNOLOGY
James A. Pritchard 301-286-7785

Work under this RTOP will evaluate alternative approaches to high data rate packet telemetry processing for parallel and nonparallel computer architecture developments applicable to the Space Station era data systems. Current packet telemetry processing systems need to be improved by as much as three orders of magnitude in order to handle the expected data rates. New computer and system architectures and processing techniques must be explored and evaluated if new systems are to be developed to meet Space Station era processing requirements. This RTOP will evaluate alternative approaches to telemetry processing (Level Zero processing and data handling functions) for parallel and nonparallel computer architecture, study high levels of telemetry processing, and study telemetry processing system architecture requirements for Space Station era data systems. In order to evaluate alternative approaches to telemetry processing, computer architecture will be matched to high data rate telemetry processing requirements. Critical telemetry functions will be selected for benchmarking and computer architecture performance will be evaluated. Programming techniques and software conversion will also be evaluated. Level Zero Processing as well as higher levels of telemetry processing will be considered while investigating telemetry processing system architecture requirements. In order to accomplish the above tasks, benchmarking of critical processing functions will be employed whenever possible.

W92-70726 **310-40-73**
Jet Propulsion Lab., California Inst. of Tech., Pasadena.
DSN DATA PROCESSING AND PRODUCTIVITY
L. P. Cooper 818-354-3252
(310-30-69)

The objective of this RTOP is to develop and demonstrate advanced computer information processing technologies to improve the capability of the Deep Space Network (DSN) to meet user needs, including: (1) reducing development costs and risks; (2) increasing the predictability, reliability, and efficiency of service; and (3) increasing the overall ease of operating the DSN. The work units in this RTOP fall into two basic areas. (1) Improvement to DSN Operational Capabilities: Advanced information processing technology can be applied to improve the way that the DSN currently operates. Work units in this category address the adoption/adaptation of Open Systems Interconnect (OSI) standards for communications, automation of monitoring and control functions, and end-to-end data flow analysis. (2) Software Management Technology: A growing fraction of the total cost to implement and maintain the DSN is attributable to software. The ability to reliably predict software development schedules enhances mission support and translates into decreased costs, improved capability, and better schedules. The work unit in this area will develop a state-of-the-art DSN software project simulation model which will allow managers to assess and predict the resource and schedule outcomes associated with changing requirements, inserting new technology, changing budget or workforce levels, and varying the development paradigms.

OFFICE OF SPACE SYSTEMS DEVELOPMENT

Advanced Programs

W92-70727 **906-11-03**
Lyndon B. Johnson Space Center, Houston, TX.
AUTONOMOUS GUIDANCE, NAVIGATION, AND CONTROL (AGN&C) BRIDGING PROGRAM
Gene McSwain 713-483-8295

The objectives of this RTOP are to develop and demonstrate technology in the areas of new sensors/sensing devices, ground and onboard guidance, navigation, and control algorithms and vehicle monitoring systems that reduce operational cost and provide an increased Shuttle launch probability. A goal is to move toward more autonomous onboard operations for future NSTS launches and unmanned launch vehicles as a means to reduce costs and time associated with prelaunch planning by minimizing the required I-Load development and verification support. A multi-center NASA team will define a technology program that utilizes centers of expertise within NASA and contractor IR&D programs to develop and demonstrate to the technology customer mature technology that can be incorporated into the Shuttle and other NASA programs. Coordination with the Level 2 Shuttle Program Office will ensure customer awareness and consent for this activity.

W92-70728 **906-11-03**
Lyndon B. Johnson Space Center, Houston, TX.
ELECTRO MECHANICAL ACTUATOR (EMA) BRIDGING
Don C. Brown 713-483-8241

This RTOP is a cooperative effort between JSC, LeRC, MSFC, SSC, and KSC. It is the top level or composite RTOP for Electrical Actuation (ELA) Technology Initiative under the Strategic Avionics Technology Working Group (SATWG). The objective is to develop and demonstrate a high power/high performance electrical actuation system in primary flight control applications. An ELA Master Plan will be developed that will establish ELA system architecture and systems engineering considerations, such as fault tolerance and redundancy management. Prototype Advanced Launch System (ALS) ELA's and man-ratable development units will be utilized to demonstrate high power electrical actuation technology readiness and hinge moment capability for advanced launch vehicle (Advanced Solid Rocket Motor, National Launch System) and other NASA vehicles (Space Shuttle, Personnel Launch System, etc.) thrust vector control (TVC), propulsion control, aerosurface, and ground support equipment applications.

W92-70729 **906-11-03**
Marshall Space Flight Center, Huntsville, AL.
LAUNCH VEHICLE ADVANCED DEVELOPMENT
Lott W. Brantley 205-544-0480

There are four tasks in this area: (1) Advanced Manufacturing Technology (Al-Li), which will develop and evaluate mechanical properties and manufacturing processes for aluminum-lithium alloys, establish baseline properties and weld processes, establish design criteria for proof of principle demonstration test tank, and then fabricate and test an External Tank size sub-length test tank; (2) Electromechanical Actuators, which will design electromechanical mechanisms to replace the currently used hydraulic devices; (3) Guidance, Navigation, and Control, which will demonstrate the capability to measure winds, using an existing ground based CO2 lidar, for input to the I-load algorithms just prior to launch (these measurements will be compared to those of the Nd:YAG lidar and the current wind measuring system); and (4) Avionics for Health Management, which will identify and demonstrate avionics architectures that implement desirable features of health management without degrading the primary avionics capabilities.

W92-70730 **906-11-03**
Lyndon B. Johnson Space Center, Houston, TX.
VEHICLE HEALTH MONITORING FOR SHUTTLE OMS/RCS
Richard J. Schoenberg 713-483-6437

The objective of this effort is to demonstrate the application of vehicle health monitoring technology to the Space Shuttle Orbital Maneuvering System (OMS) and Reaction Control System (RCS). The existing OMS/RCS fleet lead test articles, located at the NASA White Sands Test Facility (WSTF), will be used as test-beds for these health monitoring systems. The application of non-intrusive sensor technology will be demonstrated. These sensors will allow for better understanding of the OMS/RCS system operation. The emphasis for the health monitoring system implementation will be on reduction of turnaround operations required on the flight vehicles.

W92-70731 **906-13-03**
Marshall Space Flight Center, Huntsville, AL.
SUPPORT SYSTEMS ADVANCED DEVELOPMENT
Gary W. Johnson 205-544-0636

The objective of this RTOP is to provide continuation of the Phase 2 Advanced Recovery Systems Drop Test Program. The program, through March 1991, has completed eight drop tests, with additional tests remaining to complete the program. FY-91 funding is anticipated to allow two or three of these tests to be completed in FY-91, but additional funding is needed in FY-92 to complete the original objectives of demonstrating a 20,000 payload drop test using a 10,600 square foot parafoil. The existing contract NAS8-36631 will be modified by Change Order to complete the program. Time required for completion, assuming no gaps between FY-91 and FY-92 efforts, is approximately 3 to 4 months; therefore, the program should be completed by January 1992 and be ready for the initiation of Phase 3 work.

W92-70732 **906-20-03**
John F. Kennedy Space Center, Cocoa Beach, FL.
ADVANCED DEVELOPMENT
Tom C. Davis, Jr. 407-867-2780

The objective of this RTOP is to perform advanced development efforts in support of ground processing of STS and payload hardware. Advanced development of state of the art enabling technologies will be directed towards decreasing turnaround times, increasing overall efficiencies, and increasing quality and safety.

W92-70733 **906-21-03**
Lyndon B. Johnson Space Center, Houston, TX.
ADAPTIVE FUZZY LOGIC CONTROL
Robert Lea 713-483-8085

This research project will explore the use of new technologies for handling uncertainty in expert control systems development. Specifically, fuzzy controllers that adapt to a changing environment will be developed and tested in applications to space vehicle control and docking, camera tracking control, and other automation and robotics applications. A study of feasibility of the use of neural networks and other methods such as random adaptive bidirectional associative memory and adaptive resonance theory for adaptive fuzzy control will be carried out. A prototype adaptive control system will be built and performance tested in a control test environment involving both hardware and software components.

W92-70734 **906-21-03**
Lyndon B. Johnson Space Center, Houston, TX.
COMPUTER AIDED PLANNING AND SCHEDULING SYSTEM (COMPASS)
Ervin ONeal Grice 713-483-8082

The objective of this project is to continue development of artificial intelligence based application-independent planning and scheduling tools which can be applied to a wide variety of problems including STS ground flight operations planning and replanning. The approach is to develop a reusable library of Ada and X-Windows components including representations for time, activities, and resources and algorithms for scheduling activities and resources; to make these facilities available in an interactive system COMPASS (Computer Aided Scheduling System) for planning and replanning; and to use this system as a platform for the continuing development of advanced scheduling technology in collaboration with JPL and other NASA centers.

W92-70735 **906-21-03**
Lyndon B. Johnson Space Center, Houston, TX.
COMPUTER OPERATOR AUTOMATED ASSISTANCE
Mitch G. Macha 713-483-7059

The purpose of this RTOP is to adapt an automated printer controller capability to the Mission Control Center (MCC) operational real-time environment such that all technical and functional issues can be identified and resolved prior to an operational implementation. The AI printer controller capability will screen the Mission Operation Computer (MOC) and the Dynamic Standby Computer (DSC) online messages and selectively identify anomalous and status messages. The basic approach is to provide an incremental capability each fiscal year that will be exercised and evaluated by the end user in the MCC real-time environment. After the base incremental capability is provided for the fiscal year, enhancements are incorporated based upon end user comments.

W92-70736 **906-21-03**
Lyndon B. Johnson Space Center, Houston, TX.
DISTRIBUTED EARTH MODEL AND ORBITER SYSTEM (DEMOS)
Marvin L. Leblanc 713-483-4453

The Distributed Earth Model and Orbiter System (DEMOS) provides a three-dimensional simulation capability to the Mission Control Center (MCC) for support of pre-mission and real-time

analysis of attitude maneuvers, payload/orbiter lighting conditions, communications, and payload/orbiter line of sight constraints. This system integrates software from the operations division attitude and pointing operation with a three-dimensional modeling capability for the earth, orbiter, payloads, celestial sphere, and planets. Real-time simulations of actual events are provided through telemetry simulations of events that can be reviewed and analyzed pre-mission using the same interfaces that support real-time. The system provides multiple viewport capabilities modeling the orbiter cameras, star trackers, crew optical alignment sight, and any user defined viewport. The primary objectives of the FY-92 project are to complete the remaining two Level A requirements for the system, to automate the capability to analyze mission attitude profiles along with automatic line of sight processing, and to evaluate attitude/line of sight constraints for the orbiter and/or payload. The development approach will be to continue operations from within the JSC MCC using the newly installed systems. Mission Operations Directorate software will be provided to the project for modification and development of these new capabilities to be integrated into the DEMOS graphics environment.

W92-70737 **906-21-03**
Lyndon B. Johnson Space Center, Houston, TX.
INTELLIGENT COMPUTER AIDED TRAINING (ICAT)
Robert T. Savely 713-483-8105

The primary objectives of this continuing project are (1) to further refine and extend the architecture of the Intelligent Computer-Aided Training (ICAT) system originally developed to train flight dynamics officers in the procedures for Payload-Assist Module deploys from the Space Shuttle so that it can successfully address a wide variety of NASA training tasks, and (2) to develop a software environment that facilitates the adaptation of the ICAT architecture to specific training tasks by providing an integrated set of tools for knowledge acquisition, user interface development, database modification, and knowledge base editing. The refinement and extension of the original ICAT architecture will be accomplished through the production of specific ICAT systems for diverse training applications at JSC and other operational centers. These applications include the training of mission and payload specialists in using Spacelab systems and the training of engineers in performing testing and fault detection, isolation, and reconfiguration of Space Shuttle systems. The General Purpose Development Environment (GPDE) will be created by evaluating existing software tools, developing requirements for the tools that are a part of the GPDE, developing the software tools, and integrating those tools into a comprehensive, workstation-based environment for the rapid production and modification of ICAT systems. Such systems will support, not only Space Shuttle training, but also training for Space Station and future space transportation programs.

W92-70738 **906-21-03**
Lyndon B. Johnson Space Center, Houston, TX.
OVERVIEW DATABASE AND DATA SEARCH (ODDS)
Linda A. Perrine 713-483-2885

The objective is to prototype a user-interface which will be used to access the Orbiter Data Reduction Center (ODRC) when it is rehosted to an optical disk based system. The ODDS project consists of flight-to-flight overlay plotting software, conditional search of telemetry data, and a mission characteristic data base stored in a commercial off-the-shelf data base package. These technologies will be evaluated for providing rapid access and search of data from previous Shuttle flights.

W92-70739 **906-21-03**
Lyndon B. Johnson Space Center, Houston, TX.
REAL TIME DATA SYSTEM (RTDS)
Tom Kalvelage 713-483-0790
(590-12-00; 488-60-00)

The purpose of this RTOP is to immediately improve the effectiveness of Space Shuttle flight controllers by placing real time expert systems into mission control to perform telemetry monitoring and subsystem fault diagnosis. Telemetry processors are currently installed in mission control and real time Space Shuttle telemetry data is being routed into expert systems which have been developed by flight controllers. Initial results of this RTOP demonstrated that the quality of flight decision making is substantially increased by the use of the expert systems to enhance the monitoring capabilities of flight controllers. Additionally, training time is reduced and a small manpower reduction is possible through the use of these systems. The systems are developed using standard techniques and commercially available technologies such that they are portable among both existing and planned real time environments.

W92-70740 **906-21-03**
Lyndon B. Johnson Space Center, Houston, TX.
RENDEZVOUS EXPERT SYSTEM
Harry K. Hiers 713-483-2036

The objective of this RTOP is the development of rendezvous expert system software for the RGPO (Rendezvous Guidance and Procedures Officer) workstation in the Mission Control Center. The present work will build on the concepts and techniques which evolved during development of the Rendezvous Expert System (REX), an orbiter-based system designed to assist the crew in performing rendezvous and proximity operations. Requirements for the rendezvous software will be closely coordinated with JSC DM4 operations personnel. Periodic demonstrations throughout the development process will assure that the final product meets DM4's needs. As the rendezvous application software is required to operate under the standard MCC workstation executive software, implementation must also be coordinated with the MCC workstation system manager.

W92-70741 **906-21-03**
Lyndon B. Johnson Space Center, Houston, TX.
TELEMETRY AND COMMAND PROCESS APPLICATION LANGUAGE
Maryland R. Edwards 713-483-7018

The objectives of this RTOP are the following: (1) research and develop an interpreted, English-like language that can both be used as a programming language and as a user interface language which is specifically tailored to Mission Control Center (MCC) needs; (2) evaluate the reliability of this language during operations; and (3) develop a workstation tool utilizing the language developed in (1) that provides computation building and managing functions for ground support personnel. Southwest Research Institute shall perform investigation of language concepts for mission support, evaluate concepts, and work directly with the NASA Task Monitor in identifying requirements.

W92-70742 **906-21-03**
Lyndon B. Johnson Space Center, Houston, TX.
ADVANCED GRAPHICS LAB APPLICATIONS
S. Michael Goza 713-483-4695

The objective of this research will be to implement advanced graphics rapid prototyping functions including graphical tree manipulation based on user defined conditions, optimize graphics operations to increase system performance, develop a high-level engineering graphics library for non-graphics users, and incorporate advanced user interface capabilities. The approach will be to develop graphics server/client software to be utilized within an X-Window environment. This server will be ported to PHIGS/PHIGS+ resulting in a portable high-level graphics tool that can be applied to simulation and engineering analysis.

W92-70743 **906-21-03**
Lyndon B. Johnson Space Center, Houston, TX.
ADVANCED SOFTWARE DEVELOPMENT WORKSTATION (ASDW)
Charles L. Pitman 713-483-2469

The primary purpose of this project is to investigate knowledge based techniques for software and information reuse. Software development is a serious bottleneck in the construction of complex systems. An increase of the reuse of software designs and components has been viewed as a way to relieve this bottleneck. One approach to achieving software reusability is through the

development and use of software parts composition systems. Early work in this project focused on the development of a knowledge-based software components composition system prototype. While the functionality and performance of that prototype were adequate, our experience in building this system prompted us to investigate ways to exploit the use of knowledge representation, retrieval, and acquisition techniques to reduce the amount of manual effort spent in the creation of similar systems. The resulting system can be viewed as a knowledge-based environment for the development of software components composition systems. The extent of information reuse is being extended in to forward and leverage research done by the USAF in information system enterprise modeling and integrated reusable requirements and design information. In addition, the graphical user interface is extended to leverage engineering language development researched at the Naval Research Laboratory.

W92-70744 **906-22-03**
Lyndon B. Johnson Space Center, Houston, TX.
COOPERATING EXPERT SYSTEMS (COOPES)
Chris Culbert 713-483-8080

The goal of this project is to demonstrate the application of multiple, cooperating expert systems to the management of operational activities that are typical of on-board or ground based space systems. This effort focuses on planning activities associated with monitoring and controlling resource availability and usage from multiple subsystems such as electric power generation/distribution and propulsion subsystems. Our approach is to develop a hierarchy of expert systems that monitor operations for individual subsystems and then coordinate activities through higher levels of the hierarchy. Demonstration of the utility of such an architecture would help assure that incorporation of expert system automation into current vehicle upgrades and future vehicle designs could be carried out in an incremental and controllable manner. Further work will explore the variety of options for implementing distributed, cooperative systems and seek to demonstrate these advances in Shuttle applications.

W92-70745 **906-22-03**
Lyndon B. Johnson Space Center, Houston, TX.
EXTRAVEHICULAR MOBILITY UNIT (EMU) ELECTRONIC CUFF CHECKLIST
James W. McBarron, II 713-483-9254

The goal of this RTOP is to design, develop, and test an extravehicular mobility unit (EMU) electronic cuff checklist as a replacement to the current paper checklist with the end goal to demonstrate concept functionality on a Shuttle Detailed Test Objective flight experiment during a scheduled extravehicular activity (EVA) mission. This electronic cuff checklist unit will allow the astronaut to have ready access to a much larger database which is both reprogrammable and expandable. The proposed effort is to develop and fly a flight version of an electronic cuff checklist with the knowledge gained from previous Code R (FY-91) funding to develop a unit for crew evaluation (completed July 1991). Proposed activities include completion of a display technology trade study, detailed mechanical design, detailed thermal analysis/design, battery selection, Weightless Environment Training Facility (WETF) unit construction, documentation/analysis (Failure Mode and Effects Analysis non-metallics, etc.), hardware testing (WETF, thermal/vacuum, etc.) and flight hardware fabrication and demonstration.

W92-70746 **906-30-04**
Lyndon B. Johnson Space Center, Houston, TX.
DEXTEROUS MANIPULATION DEMONSTRATION
L. G. Monford 713-283-5409

Current Remote Manipulator System (RMS) operations are severely limited in performing dexterous tasks due to a lack of force feedback to the RMS operator. This RTOP explores the feasibility of equipping the RMS with a force sensing capability that will display forces and torques encountered at the end of the RMS. To attain this end, a training/demonstration unit has been developed and installed at the Manipulator Development Facility (MDF), JSC Bldg. 9A. Successful demonstrations have been performed on this device simulating heat pipe insertion, module servicing tool use, and opening and closing of drawers and latches. A force torque sensor and associated computer hardware and software has been completed by JPL. A Conceptual Design Review was completed in November, 1988; a Preliminary Design Review was completed in March 1989; and the Critical Design Review was completed December 1989. Design of a magnetic end effector and experiment carrier is complete. Prototype hardware has been completed and is undergoing final check out. Flight hardware completion is scheduled for mid-1992.

W92-70747 **906-30-04**
Goddard Space Flight Center, Greenbelt, MD.
SUPERFLUID HELIUM ON-ORBIT TRANSFER (SHOOT)
David Lindauer 301-286-2215

The Superfluid Helium On-Orbit Transfer (SHOOT) is an STS based flight experiment designed to provide advanced technology for the replenishment of payloads in space with liquid helium. The critical components, tools, hardware, software, operations, and procedures required for the replenishment of payloads with liquid helium from the shuttle and/or the space station will be defined by SHOOT. SHOOT will define the requirements to be met for payloads to be serviceable. The primary technical objectives of SHOOT are: (1) demonstrate the controlled and verified transfer of liquid helium at rates exceeding 300 liters per hour; and (2) demonstrate crew controlled transfer using aft deck computers for diagnostic operations through the use of artificial intelligence software.

W92-70748 **906-30-04**
Marshall Space Flight Center, Huntsville, AL.
FLIGHT EXPERIMENTS
Jim Harrison 205-544-0629

Task 1 of this RTOP relates to the Small Expendable Deployer System (SEDS). The objective is to complete the integration of SEDS into the Delta 2 expendable launch vehicle for a 1992 flight. The three key integration tasks remaining are: (1) analysis to determine the type and extent of mods needed by Delta 2 to accommodate SEDS; (2) design and development (or procurement) of special hardware and systems to accommodate SEDS, i.e., batteries, thermal protection system, and mounting brackets; and (3) launch site operations, i.e., physical integration, last minute electrical tests and check-out. Task 2 of this RTOP relates to the Fluid Acquisition and Resupply Experiment (FARE). The objective of the proposed flight experiment is to evaluate passive devices designed for low gravity liquid acquisition and transfer. Orbital propulsion operations and satellite servicing continue to be constrained by a lack of flight data and experience involving low gravity fluid behavior. Significant logistical and crew utilization penalties are incurred using state-of-the-art fluid resupply methods. The proposed approach is to evaluate the performance of two liquid acquisition devices (LAD's) that use capillary forces to separate liquid and vapor. This evaluation will utilize a previously flown test facility, the Storable Fluid Management Demonstration (SFMD), configured with screen channel and vane LAD's. This approach will enable essential low gravity fluids data to be obtained in a cost effective and timely manner.

W92-70749 **906-30-04**
Lyndon B. Johnson Space Center, Houston, TX.
PLASMA MOTOR GENERATOR EXPERIMENT AND TETHER APPLICATIONS
J. E. McCoy 713-483-5068

The objective is to demonstrate the operation in space of hollow cathode (HCA) plasma contactors to provide closure to and from the ionosphere of large currents at low voltage from both ends of an electrodynamic tether wire, to produce a plasma motor-generator (PMG) system suitable for both on-orbit propulsion and electrical power generation. The approach has been to build a low-cost experiment suitable for flight as a secondary payload (Payload of Opportunity). This RTOP funding reflects the flight experiment and the tether applications (data analysis) components

of this experiment. The payload has been redesigned from the existing get-away-special (GAS) configuration suitable for mounting on the Hitch-Hiker-G carrier, and is now compatible with being flown on a Delta 2 carrier using the mod-kit already developed for another payload. The new structure and harnesses for the PMG-Delta design will be fabricated, assembled with existing experiment electronics, tested and requalified and recalibrated as necessary for flight as secondary payload on the Delta 2 launch vehicle. The flight hardware will be available for delivery to launch site first quarter FY1993 for flight in second quarter FY1993.

W92-70750 **906-30-04**

Langley Research Center, Hampton, VA.

SATELLITE SERVICING - FLIGHT EXPERIMENTS SMALL EXPENDABLE DEPLOYER SYSTEM (SEDS)

K. H. Crumbly 804-864-3797

The program objective for the Tether Applications Program is to demonstrate an understanding of the underlying principles of transportation related tether applications utilizing a series of secondary payloads. The End Mass experiment objective is to obtain on-scale measurements of tether tension, center of gravity acceleration and rotation rates of an instrumented end mass while tethered from an MSFC developed SEDS deployer being flown on the second stage of a Delta 2 launch vehicle. The Small Expendable Deployer System (SEDS) demonstration is being developed at the Marshall Space Flight Center for flight on a secondary payload in the early 1993 time period. MSFC is developing the deployer mechanism and the tether; in parallel, Langley (in-house) is developing an instrumented payload to integrate onto the launch vehicle to mate with the Deployer. The Goddard Space Flight Center is responsible for the integration activities through the Delta Project Office. Goddard is also responsible for coordinating the data acquisition efforts for both the deployer and payload data.

W92-70751 **906-30-04**

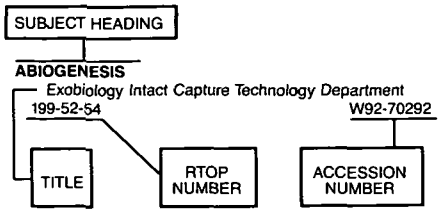
Lewis Research Center, Cleveland, OH.

ELECTRODYNAMIC TETHERS FOR PROPULSION AND POWER

Dale C. Ferguson 216-433-2298

The purpose of this RTOP is to construct a plasma diagnostics hardware package, theoretical models, and computer codes for plasma contactor electron emission and collection characteristics. The plasma diagnostics package will consist of a small electrostatic energy analyzer (for electrons) and a mass resolving energy analyzing mass spectrometer (for ions). The package is designed to be flown with and in support of the Plasma Motor Generator (PMG) Flight Experiment.

Typical Subject Index Listing



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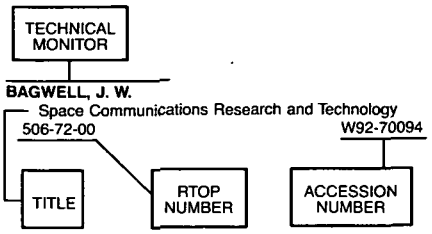

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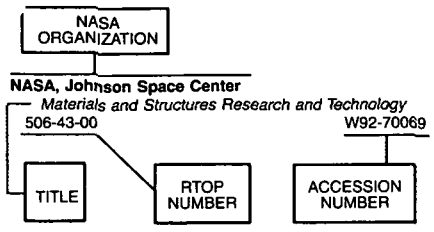

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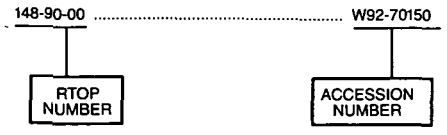

Each report covered in this publication has been assigned an RTOP number by the responsible NASA organization. They are listed here in ascending number order. By cross-referencing the accession number, the user can locate the citation and technical summary in the summary section.

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
NASA TM-105441		

4. Title and Subtitle	5. Report Date
Research and Technology Objectives and Plans Summary Fiscal Year 1992	February 1992
	6. Performing Organization Code JTT
7. Author(s)	8. Performing Organization Report No.
	10. Work Unit No.
9. Performing Organization Name and Address NASA Scientific and Technical Information Program	11. Contract or Grant No.
	13. Type of Report and Period Covered Technical Memorandum
12. Sponsoring Agency Name and Address National Aeronautics and Space Administration Washington, DC 20546	14. Sponsoring Agency Code

15. Supplementary Notes

16. Abstract

This publication represents the NASA Research and Technology Program for FY 1992. It is a compilation of the "Summary" portions of each of the RTOPs (Research and Technology Objectives and Plans) used for management review and control of research currently in progress throughout NASA. The RTOP Summary is designed to facilitate communication and coordination among concerned technical personnel in government, in industry, and in universities. The first section containing citations and abstracts of the RTOPs is followed by four indexes: Subject, Technical Monitor, Responsible NASA Organization, and RTOP Number.

17. Key Words (Suggested by Authors(s))	18. Distribution Statement
Physical Sciences Project Management Research and Development Aerospace Science Life Sciences	[redacted] Until January 1994 Subject Category 99

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price
Unclassified	Unclassified	258	

NASA-Langley, 1992